

P.O. Box 450, MSIN H6-60 Richland, Washington 99352

SEP 2 9 2010

10-ESQ-305

Ms. Jane A. Hedges, Program Manager Nuclear Waste Program Washington State Department of Ecology 3100 Port of Benton Blvd. Richland, Washington 99354

Dear Ms. Hedges:

U.S. DEPARTMENT OF ENERGY (DOE), OFFICE OF RIVER PROTECTION (ORP) RESPONSE TO THE REQUIRED ACTIONS FOR NOTICE OF CORRECTION (NOC) DOCKET #7901

References: 1.

- 1. Ecology letter from R. Skinnarland to D. A. Brockman, ORP, "Closeout of Air Emissions Permit Inspection 200 Area Diffuse and Fugitive Emissions Permit," dated August 18, 2010.
- 2. Washington State Department of Ecology NOC Approval Order Number DE00NWP-001, Revision 2, dated August 18, 2010.
- 3. Washington State Department of Ecology Notice of Correction Docket Number 7901, Site Location, Hanford 200 East Area, dated August 18, 2010.

This letter transmits the DOE ORP response to the Washington State Department of Ecology (Ecology) NOC associated with the unused AN Tank Farm diesel boiler (Reference 1 and Reference 3). The NOC identified two violations as the basis for the NOC as follows:

- 1. Failure to comply with Condition 1.B of ORDER DE00NWP-001R1 regarding firing maintenance from installation of boiler AN241-POR34-RW-BLR-101 to date.
- 2. Failure to comply with WAC 173-401-520 by falsely claiming continuous compliance with Condition 1.B of ORDER DE00NWP-001R1 regarding firing maintenance of boiler AN241-POR24-RW-BLR-101 within Air Operating Permit (AOP) #00-05-006. Renewal 1 Compliance Certifications for calendar years:
  - a. 2007,
  - b. 2008, and
  - c. 2009.

Ms. Jane A. Hedges 10-ESQ-305

Response to Item #1: Approval Condition (referred to in Reference 3 as 1.B) of ORDER DE00NWP-001R1, Attachment 1, (unchanged from Order DE00NWP-001, Attachment 2), states:

"Operation of the proposed boilers shall not exceed 720 hours per year per boiler, and be in accordance with Good Combustion Practices (GCP) to minimize emissions, based on the manufacturer's recommendations, and require the use of fuel with a Sulfur content of 0.05% or less. Periodic preventive maintenance and combustion adjustments shall be made, as necessary, to maintain GCP, but at least annually." (emphasis added)

ORDER DE00NWP-001R2 (Reference 2) provided the following revisions to the Air Operating Permit (AOP) related to the packaged boiler:

- Removes authorization to construct, install, or operate additional boilers beyond current installation
- Modifies boiler maintenance requirements to ensure appropriate control upon and after boiler startup.
- Addresses revision of Toxic Air Pollutants removed from WAC 173-460 in June 2009, addresses editorial changes due to revision of ORDER 94-07 on May 7, 2008, regarding emissions control for 241-AY and 241-AZ tank farms.

Approval Condition 1.B of ORDER DE00NWP-001R2, states:

- "B. The package boiler
  - i. Shall not exceed 720 hours per year of operation;
  - ii. Shall be fired with fuel with a Sulfur content of 0.05% or less;
  - iii. Shall be maintained in accordance with GCP to minimize emissions, based on the manufacturer's recommendations;
  - iv. Shall undergo periodic preventative maintenance and combustion adjustments, as necessary, to maintain GCP, at least annually after initial operation." (emphasis added)

Consistently, the conditions of these orders address Good Combustion Practices (GCP) for operation of the boilers periodically and annually for the purpose of minimizing emissions. It has been WRPS' and ORP's interpretation that these conditions were applicable only following initial operation of the equipment. It is noted that the recent changes in approval conditions language, provided by ORDER DE00NWP-001R2, requiring the need for periodic preventative maintenance and combustion adjustments to maintain GCP at least annually "after initial operation" are consistent with our interpretation. The package boiler was installed, but has

never been operated. As such, the package boiler has not produced/generated air emissions. With no immediate anticipation for commissioning or start-up, fire maintenance has not been considered necessary, and thus has not been performed. ORP would like to initiate discussions regarding removal of this boiler from the AOP.

Response to Item #2: The general portion of the AOP refers to authorization to operate air emission units. ORP and Washington River Protection Solutions, LLC (WRPS) have interpreted the intent of the AOP conditions to be applicable to operating emission units and impacts on air emissions. The AOP's specific approval conditions address GCP for operation of the boilers periodically and annually for the purpose of minimizing emissions. It has been the interpretation that these conditions were applicable only following initial operation of the equipment. As stated above, the recent change to the approval conditions to clarify the need for preventative maintenance and combustion adjustments to maintain GCP at least annually after initial operation of the equipment appear to substantiate our interpretation. The package boiler was installed, but has never operated. As such, the package boiler has not produced/generated air emissions.

As stated in Reference 3, in June 2007 (certification for Calendar Year [CY] 2006), DOE certified the compliance status of the boiler as "Not Applicable," and in the June 2007 certification provided the following justification: "The boiler for this project has been installed for 241-AN and 241-AZ tank farms. This boiler has not been made operational (a future requirement). No activities were conducted requiring the use of the NOC during the reporting period."

In October 2007, Ecology requested clarification of facility certifications, including "DE00NWP-001" and provided guidance regarding certifications of "Not Applicable" versus "Continuous", see Attachment 3. Based on the guidance provided by Ecology, which was incorporated into guidance provided to all Hanford prime contractors by Fluor Hanford to support CY 2007 AOP compliance certification (Attachment 4), and our interpretation that the approval conditions were applicable only if the boiler was placed in operation, subsequent certifications (i.e., certifications for CY 2007, 2008, and 2009) were revised to "Continuous." A similar statement clarifying the status of the boiler as not having been made operational has also been provided with each certification.

We believe that our certification of the permit conditions was appropriately based on the Ecology guidance and respectfully disagree with Ecology's finding in Reference 3. We feel our assertions are further supported by Ecology's April 2010 acceptance of the annual certification statements "as complete and appropriate statement of compliance," as stated in Attachment 5, and further supported by Ecology's signed inspection report on the subject boiler system, dated May 11, 2010 (Attachment 6), which indicated "No actions needed to achieve compliance." Additionally, on June 28, 2010, a meeting was held between Ecology, ORP, and WRPS representatives to discuss the AOP Certification in process for the Compliance Status Report

Period January 1, 2009, through December 31, 2009. The compliance demonstration method and compliance status for the GCP and preventative maintenance related approval conditions were discussed and WRPS and ORP were of the understanding at the conclusion of the meeting that all parties in the meeting were in agreement with the method and status discussed. Subsequently, the compliance status for the boiler was certified by DOE as "continuous."

As evidenced by the finding in Reference 3, confusion or misunderstanding remains regarding the language that an appropriate certification statement for a permitted unit that is not in operation and not generating emissions should contain. As such, we would like an opportunity to discuss ORDER DE00NWP-001R2 (Reference 2) to establish a common understanding of the meaning, intent, and subsequent certification of the permit conditions to prevent further certification issues.

The NOC, Section III.1, also identified six specific actions to be completed by September 30, 2010. Listed below are the actions with the accompanying information requested by Ecology as appropriate:

1. Report the date of landing of boiler AN241-POR34-RW-BLR-101 in its current location. (NOC Section III.1.a)

A search of our records for Boiler AN241-POR34-RW-BLR-101, although inconclusive, indicates that the boiler arrived at the Hanford site around September 1998. Unfortunately, we cannot determine from the records available when the equipment was placed in its current location west of AN Tank Farm. However, in CY 2002, DOE identified in the AOP compliance status certification that the "boilers for the project have not been installed." For CY 2003, DOE reported that "The boiler for this project has been installed for 241-AN, and 241-AZ tank farms. This boiler has not been made operational (a future requirement)." From this information, we can only conclude that the boiler was landed and installed to its current configuration sometime within CY 2003.

2. Submit copies of results of all tests performed upon boiler AN241-POR34-RW-BLR-101 regarding firing performance, firing adjustments, and emissions control. (NOC Section III.1.b)

Boiler AN241-POR34-RW-BLR-101 has not operated since landing at the AN Tank Farm site. It has been our interpretation that because the equipment has not been placed in operation, testing and maintenance of the boiler is not required. As a result, there have been no firing performances, firing adjustments, or emission control tests performed and therefore, no results of such tests are available.

- 3. Submit documentation detailing boiler AN241-OOR34-RW-BLR-101 manufacturer's recommendations for preventative maintenance of boilers which are anticipated to be in long-term disuse (laid up). (NOC Section III.1.c)
  - Cleaver-Brooks Operations, Service and Parts Manual (Attachment 7) has been provided for your reference. Chapter 3, Section I provides instruction for preparation of extended lay-up of the waterside of the boiler. It is our interpretation that these instructions are intended for package boilers in operation, or package boilers being placed in lay-up following operation of the equipment. As this package boiler was never operated, it has been our interpretation that no periodic or preventative maintenance program was required for this equipment.
- 4. Submit documentation indicating all preventative maintenance procedures conducted upon boiler AN241-POR34-RW-BLR-101 for long term disuse (laid up). (NOC Section III.1.d)
  - As stated previously, it has been the interpretation that because the package boiler has never been placed in operation that no preventative maintenance was required. As a result, there have been no preventative maintenance procedures conducted upon the boiler and therefore, no documentation indicating such procedures are available.
- 5. Prepare and submit a statement indicating compliance with, or deviation from each of the manufacturer's recommendations as supported by submittals in III.1.c and III.1.d. The reported statement shall be certified in the manner of WAC 173-401-520. (NOC Section III.1.e)

The subject package boiler has never been placed in operation. Therefore, no preventative maintenance of the boiler has been performed.

I certify, pursuant to WAC 173-401-520, that, based on information and belief formed after reasonable inquiry, that statements and information provided in response to III.1.c and III.1.d of Reference 3 (items 3 and 4 above) are true, accurate, and complete.

D. A. Brockman

Manager

6. Establish and maintain a log or record system for the recording of operating hours and maintenance of boiler AN241-POR34-RW-BLR-101. The log or record system shall be subject to Ecology inspection. (NOC Section III.1.f)

Boiler AN241-POR34-RW-BLR-101 has not been placed in operation and has never been operated. Therefore, no maintenance was required or performed. WRPS systems for operations and maintenance log and record keeping for operational equipment are in place and maintained. If and when the boiler is placed in operation, operating and maintenance logs for the system will be established and implemented to record operating hours and maintenance of the system. Such logs will be available for Ecology inspection.

If you have any questions, please contact me, or your staff may contact Lori A. Huffman, Director, Environmental Compliance Division, (509) 376-0104.

Sincerely,

Office of River Protection

ESQ:DWB

Attachments: (7)

cc: See page 7

#### cc w/attachs:

O. S. Wang, Ecology

R. H. Anderson, MSA

J. W. Donnelly, WRPS

Administrative Record

Environmental Portal, LMSI

WRPS Correspondence

#### cc w/o attachs:

- J. A. Bates, CHPRC
- J. Cox, CTUIR
- S. Harris, CTUIR
- S. L. Dahl, Ecology
- D. Hendrickson, Ecology
- G. Bohnee, NPT
- K. Niles, Oregon Energy
- D. E. Jackson, RL
- J. A. Voogd, WRPS
- P. J. Martell, WDOH
- F. R. Miera, WRPS
- L. L. Penn, WRPS
- R. Jim, YN

# Attachment 1 10-ESQ-305

Number: 00-05-006 (Hanford AOP 2006 Renewal)

#### Attachment 1

Number: 00-05-006 (Hanford AOP 2006 Renewal)

State of Washington Department of Ecology (Ecology)

Nuclear Waste Program

3100 Port of Benton Blvd.

Richland, Washington 99354

The permittee is authorized to operate the air emission units identified in this Air Operating Permit Number 00-05-006 and all insignificant emission units not specifically identified in this permit.

Dated at Richland, Washington this 29th day of December 2006.

Reviewed by:

Doug Hendrickson, P.E.

Professional Engineer Reviewer

State of Washington Department of Ecology

Approved by:

Jane Hedges

Program Manager, Nuclear Waste Program
State of Washington Department of Ecology

/2/27/65 Date Discharge Point

200 Area Diffuse/fugitive-Tank Farms

200 Area, Tank Farms - Mixer Pumps

Requirement Citation (WAC or Order Citation):

DE00NWP-001

**Condition Approval** 

6/13/2000

Condition:

The data obtained in the course of monitoring worker exposure will be used by the Permittee as an administrative control measure to verify that VOC emissions do not exceed 500 parts per million (PPM). The 500 PPM level will be used as an indicator to facilitate field monitoring of potential VOC emissions, using the existing Industrial Hygiene

equipment.

Periodic Monitoring:

VOC measurements from each stack.

Test Method:

Organic Vapor Analyzers (OVAs) or similar instruments.

Test Frequency:

At least once per year during mixer pump operations. If mixer pumps

do not operate, no monitoring is required.

Required Records:

VOC measurement.

State-Only

No.

Calculation Model

Not applicable.

Requirement Citation (WAC or Order Citation):

DE00NWP-001

**Condition Approval** 

6/13/2000

Condition:

Operation of the proposed boilers shall not exceed 720 hours per year per boiler, and be in accordance with good combustion practices (GCP) to minimize emissions, based on the manufacturer's recommendations, and require the use of fuel with a Sulfur content of 0.05% or less. Periodic preventive maintenance and combustion adjustments shall be

made, as necessary, to maintain GCP, but at least annually,

Periodic Monitoring:

Recordkeeping.

Test Method:

Not specified (see Required Records below).

Test Frequency:

Annually,

Required Records:

1. Operating logs showing all hours of operation.

2. GCP - Preventive maintenance and combustion adjustment records. 3. Records of vendor documentation or fuel analysis documenting procurements of diesel fuel with sulfur content of 0.05% or less once per

year.

State-Only

No.

Calculation Model

Not applicable.

Discharge Point

200 Area Diffuse/fugitive-Tank Farms

200 Area, Tank Farms - Mixer Pumps

Requirement Citation (WAC or Order Citation): DE00NWP-001

**Condition Approval** 

2/15/2005 (Revision 1)

Condition:

Tanks:

A new Notice of Construction will be required, if total emissions of toxic air pollutants exceed the SQER, unless dispersion modeling demonstrates that emissions would continue to result in concentrations

less than the ASILs. Results of any such dispersion modeling

demonstrations/calculations will be maintained on file at the tank farms

and made available upon inspection.

Periodic Monitoring:

Analyze each proposed change to determine if emissions would exceed

an SQER or ASIL.

Test Method:

Not specified. Not applicable.

Test Frequency: Required Records:

Results of analyses.

State-Only

Yes.

Calculation Model

Not applicable.

Requirement Citation (WAC or Order Citation):

DE00NWP-001

**Condition Approval** 

6/13/2000

Condition:

An updated schedule of installation and operation activities will be

made available upon request.

Periodic Monitoring:

Recordkeeping. Not specified.

Test Method:

Not applicable.

Test Frequency: Required Records:

Copy of updated schedule.

State-Only

Yes.

Calculation Model

Not applicable.

**Discharge Point** 

200 Area Diffuse/fugitive-Tank Farms

200 Area, Tank Farms - Mixer Pumps

Requirement Citation (WAC or Order Citation):

DE00NWP-001

**Condition Approval** 

6/13/2000

Condition:

Tanks:

Notification will be made ten (10) days prior to initiating waste retrieval

operations in each tank covered by this order.

Periodic Monitoring:

Recordkeeping.

Test Method: Test Frequency: Not specified. Not applicable.

Required Records:

Copy of notification.

State-Only

Yes.

Calculation Model

Not applicable.

# Attachment 2 10-ESQ-305

Ecology letter from M. Wilson to J. J. Bevelacqua, ORP, "Nonradioactive Air Emissions Notice of Construction (NOC) for Installation and Operation of a Waste Retrieval System in Double-shell Tanks Approval Order No. DE 00NWP-001





#### STATE OF WASHINGTON

#### DEPARTMENT OF ECOLOGY

1375 W. 4th Avenue • Kennewick, Washington 99336-6018 • (509) 735-7581

June 13, 2000

Dr. Joseph J. Bevelacqua, Acting Assistant Manager Environmental, Safety, Health and Quality United States Department of Energy Office of River Protection P.O. Box 450 Richland, Washington 99352

Dear Dr. Bevelacqua:

Re: Nonradioactive Air Emissions Notice of Construction (NOC) for Installation and Operation of a Waste Retrieval System in Double-shell Tanks Approval Order No. DE 00NWP-001

Enclosed is Order No. DE 00NWP-001. If you have any questions concerning the content of this document, please contact Jerry Hensley at (509) 736-3017. The enclosed Order may be appealed. The appeal procedures are described in the Order.

Sincerely.

Michael Wilson

cc: Don Carrell, CHG
Fran DeLozier, CHG
John Bates, FDI
Joseph Panasiti, FDI
Administrative Record:

muelaich

J. R. Wilkinson, CTUIR
Pat Sobotta, Nez Perce Tribe
Russell Jim, YIN
Mary Lou Blazek, OOE

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#### STATE OF WASHINGTON DEPARTMENT OF ECOLOGY

IN THE MATTER OF APPROVING A	) NOC APPROVAL ORDER
NONRADIOACTIVE AIR EMISSIONS NOTICE O	F) NUMBER: DE00NWP-001
CONSTRUCTION FOR INSTALLATION AND	)
OPERATION OF A WASTE RETRIEVAL SYSTEM	M)
IN DOUBLE-SHELL TANKS FOR	)
THE DEPARTMENT OF ENERGY	)
OFFICE OF RIVER PROTECTION	)

To: Dr. Joseph J. Bevelacqua, Acting Assistant Manager Environmental, Safety, Health and Quality United States Department of Energy Office of River Protection P.O. Box 450 Richland, Washington 99352

#### FINDINGS:

On May 17, 2000, the United States Department of Energy, Office of River Protection (USDOE-ORP), submitted a Notice of Construction (NOC) application for installation and operation of a waste retrieval system in double-shell tanks (DSTs), located on the Hanford Site 200 Area.

In relation to the above, the Washington State Department of Ecology, pursuant to Revised Code of Washington (RCW) 70.94.152, Washington Administrative Code (WAC) Chapters 173-400, and 173-460, makes the following determinations:

- 1. The proposed project, if constructed and operated as herein required, will be in accordance with applicable rules and regulations, as set forth in WAC Chapters 173-400, and 173-460, and the operation thereof, at the location proposed, will not result in ambient air quality standards being exceeded.
- 2. The proposed project, if constructed and operated as herein required, will provide all known, available, and reasonable methods of emission control.

#### 1. LAWS AND REGULATIONS

All proposed activities performed in support of installation and operation of a waste retrieval system in DSTs by the USDOE-ORP, referred to herein as the Permittee, shall comply with all requirements as specified in:

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- RCW Chapter 70.94, Washington Clean Air Act;
- WAC Chapter 173-400, General Regulations for Air Pollution Sources;
- WAC Chapter 173-460, Controls for New Sources of Toxic Air Pollutants.

#### 2. EMISSIONS

A. All emissions from the construction activities are expected to be fugitive emissions. Volatile Organic Compound (VOC) emissions and Toxic Air Pollutants (TAPs), are not expected to be released during the construction activities.

The construction activities potentially could increase the rate of fine particulate matter (PM-10), and particulate matter (PM). An estimated total of 8,220 cubic yards of soil will be excavated over the eleven (11) year period of these activities. The estimated emissions from the total 8,220 cubic yards of soil is 0.05 ton of PM, and 0.21 ton of PM-10.

B. New emissions are expected from the package boilers when placed in service. The estimated emissions are reflective of three (3) boilers operating at the same time, for a maximum of 720 hours per year per boiler.

Poliutant	Estimated boiler
·	emissions
NOx (oxides of Nitrogen)	1.94 tons/year
CO (Carbon Monoxide)	0.77 tons/year
VOCs (volatile organic compound)	0.33 tons/year
PM-10 (fine particulate matter)	0.28 tons/year
SOx (oxides of Sulfur)	0.70 tons/year
Nitric Oxide	1.94 tons/year

- C. Increased emissions of TAPs (ammonia) at the source tank during mixing, and at the receiver tank during a waste transfer, are expected from the affected tank farm stacks, during normal operations of the waste retrieval systems. It is anticipated that the most significant emissions will occur during startup, and a short period thereafter. Once equilibrium is reached in the headspace, it is anticipated that concentrations will level off.
- D. There are no directly applicable sample data from DSTs, or waste retrieval operations, that can be used to calculate potential emissions. Therefore, sampling data and flame ionization detector (FID) readings obtained during the 1999 sluicing operations at the 241-C-106 tank, and the resultant emissions predictions (00-OSS-086), with the exception of ammonia, will be used to represent emissions from these waste retrieval

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> operations. Sluicing is a more aggressive process than waste retrieval and, therefore, has been used to provide a conservative estimate of potential emissions.

> Ammonia was modeled separately because ammonia is generated through radiolysis regardless of the ventilation flow rate in the tank headspace, and once mixing begins, previously generated, but trapped ammonia, will be made available for release. The highest liquid waste ammonia concentration from the affected tanks listed in the NOC was used in the Schumpe Model to estimate headspace concentrations at the receiving tank during a waste transfer (RPP-4941; HNF-SD-WM-CN-118). The Class A and B constituents, headspace concentrations, and estimated emissions are shown in Table 2 of the NOC.

- 3. BACT WAC 173-400-113 requires the use of Best Available Control Technology (BACT) to control emissions. Since emissions will be below the threshold levels contained in WAC 173-400-110(5)(d), no technology controls are warranted.
- 4. T-BACT -- WAC 173-460-040(4)(b) requires the use of Best Available Control Technology for Toxics (T-BACT) to control toxic emissions. Since all emissions resulting from the proposed operations are in compliance with the WAC 173-460 Acceptable Source Impact Levels (ASILs), no additional controls are warranted.

#### ADDITIONAL FINDINGS

The proposed project consists of the installation and operation of one (1) waste retrieval system (mixer pumps and other associated equipment), in the 241-AP-102, 241-AP-104, 241-AN-101, 241-AN-102, 241-AN-103, 241-AN-104, 241-AN-105, 241-AN-107, 241-AW-101, 241-AW-103, 241-AW-104, 241-AY-101, 241-AY-102, 241-AZ-101, 241-AZ-102, 241-SY-101, 241-SY-102, and 241-SY-103 double-shell tanks (DSTs). Generally, this includes removal of existing equipment, installation of new equipment, and construction of new ancillary equipment and buildings. The pumps will operate in a batch mode, as needed, to provide waste feed for immobilization into a solidified waste product (i.e., glass logs). The waste capacity of the tanks will not be altered, nor will the ventilation or emissions control systems. Further, resultant emissions of all toxic air pollutants (TAPs), except ammonia, will be below the associated Small Quantity Emission Rate (SQER). Ammonia will be below its SQER, but above its twenty-four (24) hour SQER. Installation of a waste retrieval system in these DSTs is scheduled to take place between the years 2000 and 2011.

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#### 1. PROCESS DESCRIPTION

The upgrades at each tank farm will include the following major components.

#### a) New In-Tank Equipment

New in-tank equipment will be the following:

- Installation of one (1) or two (2) mixer pumps in each tank for mobilizing the settled solids, with the exception of 241-AY-101 and -102. Each pump will be capable of mixing waste at approximately 10,400 gallons per minute. The 241-AY-101 and -102 tanks will have four (4) pumps installed, capable of mixing waste at a total of approximately 4,800 gallons per minute.
- Installation of a high-pressure spray wash system to be used for future decontamination of the mixer pumps, as the pumps are removed from the tank.
- Installation of one (1) pump in each tank for the transfer of waste. The pumps will be capable of maintaining a variable waste transfer at a rate of up to 140 gallons per minute.
- Installation of one (1) closed circuit television system per tank as required.

#### b) New Ancillary Equipment and Buildings

New ancillary equipment and buildings will be as follows:

- Construction of a new instrument building, an annex to an existing instrument building, or modifications to an existing instrument building, as needed to house retrieval instrumentation/electrical equipment and operator stations.
- Installation of electrical power and instrument cables, and other utility tie-ins and/or upgrades (e.g., sanitary and raw water, and telecommunications).
- Construction of up to three (3) caustic supply/dilution systems. The caustic supply systems will be used to bring waste properties into compliance with the feed specifications, and to flush and preheat transfer lines. Each system will be capable of providing approximately 140 gallons per minute of pH-adjusted water. Each system will consist of a package boiler, a chemical injection pump, a diluent/flush pump, a diluent/flush tank (approximately 5,000 gallons), and a spill containment pad for caustic delivery trucks. Each boiler is rated at 250-boiler horsepower (8.369 million British Thermal Units [BTUs] per hour), and is \$2 percent efficient.
- The boilers will run on No. 2 diesel oil, not to exceed 0.05 percent Sulfur by weight.

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- Installation of new process jumpers inside pump pits, installation of a new valve pit, and new pump pit cover blocks as required.
- Installation of new piping: double-contained waste transfer piping, and water and diluent piping, to and from the process pits.

## c) Removal, Relocation, Replacement, Decontamination, and Demolition of Existing Equipment

- The existing flexible receiver equipment will be used to remove and decontaminate (to acceptable levels) the long-length, waste contacting pieces of equipment. The remaining equipment will be removed using the general bag-out process (sleeving equipment with plastic or piping as removed). Various in-tank equipment, such as the following, will be removed from the tanks to make room for the waste retrieval equipment, or will be replaced with equivalent equipment built to withstand the mixer pump jet forces:
  - Removal of existing mixer pumps and air-lift circulators as needed
  - Removal of transfer pumps, slurry distributors, drop-leg jumpers, thermocouple probes, and multi-function instrument trees as required
  - Removal and replacement of existing jumpers and cover blocks from pump and valve pits
  - ✓ Relocation of closed-circuit television cameras to different risers as needed
  - Replacement of temperature probes as required

#### d) Waste Staging and Retrieval Process Overview

The retrieval process will transfer waste from a source tank to a receiving tank, or from a source tank to a waste treatment facility, as feed stock. Mixing and dilution of the waste could take place at the source tanks to meet transfer line specifications, i.e., solids content must be within a predetermined amount. Waste at the receiving tanks also could be conditioned and/or diluted, to deliver compliant waste to a waste treatment facility. Incoming waste will be staged in a tank until enough waste has been accumulated to transfer, and the treatment facility is ready to receive, a batch. The mixer pump will be operated to maintain waste uniformity during staging and to mix the waste for a short period before being transferred.

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Mixer pump operation will be in batches of up to 450 hours per year per tank. The mixer pump will be operated at full speed until waste samples verify that adequate mixing has been achieved. If dilution or conditioning is needed, the pH and temperature of the diluent will be adjusted by means of a caustic supply system. Once the waste is verified as acceptable, the transfer lines will be preheated, flushed with diluent, and a waste transfer to a receiving tank, or to a treatment facility will begin. After the transfer, the lines will be flushed with diluent.

#### 2. VENTILATION AND EMISSIONS CONTROL SYSTEMS

The tank farms ventilation and control systems are designed to maintain a negative pressure, remove process and radiolytic heat, and remove water vapor and particulates for each primary vapor space. No changes will be made to the existing ventilation, or emissions control systems currently in place at the affected tank farms, because these systems have been determined adequate to remove additional heat generated by the mixer pumps. A thermal evaluation showed that the operation of one (1) 300 horsepower mixer pump would result in slow, controlled, and easily observable increases in waste temperature without compromising the tank operating limits. The maximum expected temperature increase at the tank, due to operation of a mixer pump, is approximately 2.3 EF per day (WHC-SD-W211-ER-002). The cumulative effect at the filtration system, however, is negligible, because the exhaust streams, from the tanks with mixer pumps, are diluted when mixed with the air streams from the other tanks in the tank farm before entering the filtration system.

The AN, AP, and AW Tank Farms ventilation and control systems are very similar. A description is provided as follows with the differences for the AY/AZ and SY systems noted as applicable.

Inlet air is provided through tank dome penetrations via gaps in the pit cover blocks of the tanks (AP Tank Farm), or through an inlet air riser equipped with a prefilter and a single stage high-efficiency particulate air (HEPA) filter (AN, AW, and AY/AZ Tank Farms). Air is exhausted from each tank independently to a common header that continues on to a central exhaust station. The exhaust station consists of two (2) filtration subsystems and the stack. Either subsystem can collectively ventilate all the tanks together. Only one (1) subsystem operates at a time, while the other remains in standby as a backup. The SY exhaust station consists of one (1) filtration system and a stack. A portable exhauster is stationed on location and used as the backup.

Each filtration subsystem for the AN, AP, and AW exhaust stations consists of a de-entrainer, for the removal of moisture; a heater that is operated intermittently as needed for lowering the relative humidity; a pre-filter for reducing the number of large particles; two (2) stages of HEPA filters; and an exhaust fan. The AY/AZ filtration system consists of a condenser; a high-efficiency mist eliminator (HEME); and two (2)

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- parallel filter trains consisting of a heater that operates intermittently, one (1) stage HEPA filter, one (1) stage high-efficiency gas absorber (HEGA), one (1) stage HEPA filter and a fan, with both trains exhausting to the stack.
- The portable exhauster at the SY Tank Farm consists of a de-entrainer, heater (declared non-functional and removed from service), prefilter, two (2) stages of HEPA filters, an exhaust fan, and the stack. Annually, the HEPAs in all the systems are tested individually (per ASME N510), to a minimum efficiency of 99.95 percent for the removal of particulates with a median diameter of 0.3 microns.

Toxic constituent concentrations are in compliance with their respective ASILs at the respective points of emission, as opposed to the Hanford Site boundary. Therefore, no changes to the current controls are required.

THEREFORE, IT IS ORDERED that the project as described in said Notice of Construction application, and more specifically detailed in plans, specifications, and other information, submitted to the Department of Ecology in reference thereto, is approved for construction, installation and operation, provided the following conditions are met:

#### APPROVAL CONDITIONS:

#### 1. TOTAL EMISSION LIMITS

- A. The activities described in the Notice of Construction application will be permitted without requiring additional control technologies, provided that the total emissions from all activities will not result in exceedance of WAC 173-460 ASILs.
- B. Operation of the proposed boilers shall not exceed 720 hours per year per boiler, and be in accordance with good combustion practices (GCP) to minimize emissions, based on the manufacturer's recommendations, and require the use of fuel with a Sulfur content of 0.05% or less. Periodic preventive maintenance and combustion adjustments shall be made, as necessary, to maintain GCP, but at least annually. Per Ecology's request, the USDOE shall demonstrate the effectiveness of GCP to Ecology during normal operation of the boilers.
- C. A new Notice of Construction will be required, if total emissions of toxic air pollutants exceed the SQER, unless dispersion modeling demonstrates that emissions would continue to result in concentrations less than the ASILs. Results of any such dispersion modeling demonstrations/calculations will be maintained on file at the tank farms and made available upon request.

Notice of Construction Approval Order No. DE00NWP-001 June 13, 2000 Page 8 of 11

D. A new NOC also will be required, if total emissions of criteria pollutants exceed the WAC 173-400-110 thresholds.

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#### 2. GENERAL REQUIREMENTS

- A. Notification will be made ten (10) days prior to initiating waste retrieval operations covered by this Order.
- B. An updated schedule of installation and operation activities will be made available upon request.

#### 3. EMISSION CONTROL MONITORS

- A. No sampling is required for nonradioactive air emissions because all contaminant emissions are below their respective SQERs, with the possible exception of ammonia. Estimated ammonia emissions were calculated to be above the twenty-four (24) hour SQER, but below the annual SQER and the ASIL.
- B. However, Organic Vapor Analyzers (OVAs), or other similar instruments for detecting fugitive organic emissions, as part of the Hanford Industrial Hygiene program to monitor worker exposure, will be used to monitor for VOCs.
- C. The data obtained in the course of monitoring worker exposure will be used by the Permittee as an administrative control measure to verify that VOC emissions do not exceed 500 parts per million (PPM). The 500 PPM level will be used as an indicator to facilitate field monitoring of potential VOC emissions, using existing Industrial Hygiene equipment.

#### 4. MANUALS

Operation and Maintenance (O&M) Manuals for all equipment associated with the proposed activities that have the potential to affect emissions to the atmosphere shall be developed and followed. Manufacturers' instructions may be referenced. The O&M manuals shall be updated to reflect any modifications of the process or operating procedures. Emissions that result from failure to follow the requirements of the O&M Manuals or manufacturer's instructions may be considered proof that the equipment was not properly operated, maintained, and tested. Copies of the O&M Manuals shall be available to Ecology upon request.

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#### 5. INITIAL NOTIFICATIONS & SUBMITTALS

All notifications and submittals required under these Approval Conditions shall be sent to:

Washington State Department of Ecology Nuclear Waste Program 1315 West Fourth Avenue Kennewick, Washington 99336-6018

#### 6. MONITORING and RECORDKEEPING

Specific records shall be kept on-site by the Permittee and made available for inspection by Ecology upon request. The records shall be organized in a readily accessible manner and cover a minimum of the most recent sixty (60) month period. The records to be kept shall include the following:

- A. Work Package activities related to site occupational health sampling/monitoring.
- B. Evaluations of additions or changes to demonstrate compliance with the ASIL limits (for additions or changes not otherwise exempt under WAC 173-400 or -460).
- C. Boiler logs, including operating time, preventive maintenance and combustion adjustments to maintain GCP, and certification that boiler fuel contains less than 0.05% Sulfur, will be maintained on file at the tank farms and made available to Ecology upon request.

#### 7. ASIL EVALUATION

The methodology used in evaluating emissions, to demonstrate potential total emissions are below the ASILs as described in Section 7.0 of the NOC application, may be modified with Ecology's concurrence.

#### 8. GENERAL CONDITIONS

- A. Visible Emissions: No visible emissions shall be allowed beyond the property line.
- B. Commencing/Discontinuing Construction and/or Operations: This approval shall become void if the proposed activities are not commenced within eighteen (18) months after receipt of this Order approving the NOC application, or if activities are discontinued for a period of eighteen (18) months.

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June 13, 2000
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C. Compliance Assurance Access: Access to the source by EPA or Ecology shall be allowed for the purposes of compliance assurance inspections. Failure to allow access is grounds for revocation of the Order approving the NOC.

J

- D. Modification to Facility or Operating Procedures: Any modification to any equipment or operating procedures, contrary to information in the NOC application, shall be reported to Ecology at least sixty (60) days before such modification. Such modification may require a new, or amended, NOC Approval Order.
  - E. Activities Inconsistent with this Order: Any activity undertaken by the Permittee or others, in a manner that is inconsistent with the NOC application, and this determination, shall be subject to Ecology enforcement under applicable regulations.
  - F. Obligations under Other Laws or Regulations: Nothing in this Order shall be construed to relieve the Permittee of its obligations under any local, state, or federal laws, or regulations.

Nothing in this approval shall be construed as obviating compliance with any requirements of law, other than those imposed pursuant to the Washington Clean Air Act, and rules and regulations thereunder.

A two (2) month testing and break-in period is allowed, after any part or portion of this project becomes operational, to make any changes or adjustments required to comply with applicable rules and regulations pertaining to air quality and conditions of operation imposed herein. Thereafter, any violation of such rules and regulations, or of the terms of this approval, shall be subject to the sanctions provided in Chapter 70.94 RCW.

Authorization may be modified, suspended or revoked (in whole or part) for cause, including, but not limited to, the following:

- 1. Violation of any terms or conditions of this authorization;
- 2. Obtaining this authorization by misrepresentation, or failure to disclose fully all relevant facts.

The provisions of this authorization are severable and, if any provision of this authorization, or application of any provisions of this authorization, to any circumstance, is held invalid, the application of such provision to their circumstances, and the remainder of this authorization, shall not be affected thereby.

Notice of Construction Approval Order No. DE00NWP-001 June 13, 2000 Page 11 of 11

Any person feeling aggrieved by this ORDER may obtain review thereof by application, within thirty (30) days of receipt of this ORDER, to:

Pollution Control Hearings Board P.O. Box 40903 Olympia, Washington 98504-0903

Concurrently, copies of the application must be sent to:

Washington State Department of Ecology P.O. Box 47600 Olympia, Washington 98504-7600

Washington State Department of Ecology 1315 West Fourth Avenue Kennewick Washington 99336-6018

These procedures are consistent with the provisions of Chapter 43.21B RCW, and the rules and regulations adopted thereunder.

DATED at Kennewick, Washington, this 13th day of June 2000.

PREPARED AND REVIEWED BY:

Jerry Hensley, P.E.

APPROVED BY:

Michael A. Wilson

# Attachment 3 10-ESQ-305

E-mail from M. F. Jarvis, RL, to D. Hendrickson, Ecology, "RE: AOP Comp Certification Clarifications," dated October 22, 2007.

From:

Jarvis, Mary F.

Sent:

Monday, October 22, 2007 12:56 PM

To:

Hendrickson, Douglas (ECY)

Cc:

Beam, Thomas G; Wang, Oliver S; 'Schmidt, John W (DOH)'; Penn, Lucinda L; Bowser, Dennis W; Bates, John A; Aldridge, Theresa L (PNSO); Homan, Nancy A; Woodruff, Rodger K; Woolard, Joan G; Barnett, Matthew; Weiher, Patrick

A; Kemp, Christopher J; Marvin, Marla: Barfuss, Brad C:

'rdhaggar@bechtel.com'

Subject:

**RE: AOP Comp Certification Clarifications** 

Importance:

High

#### Doug,

Thank you for the initial feedback on the content of the 2006 Annual AOP Compliance Certification Report (DOE/RL-2007-04). Any suggestions to help improve the quality of the report or clarify Ecology's expectations are welcomed. The use of your close-out letter on the review of the annual compliance certification report seems a reasonable manner to provide such suggestions. We request an opportunity to meet with you and discuss your intended draft guidance prior to issuance. This will allow us to better understand your concerns and provide potential clarifications before it is formally issued. Please advise when you are ready to proceed to that step in the process and I will arrange a meeting with the appropriate personnel.

With regards to your two specific questions on 296-S-15 and J-CWC-001, the following information is provided to assist in your review of the 2006 AOP compliance certification.

#### 296-S-15

296-S-15 is the common stack designation/alias for emission point 200W P-296SX-001. Discharge point 200W P-296SX-001 was correctly listed in the 2004 and 2005 Certifications. It was mistakenly listed by its 296-S-15 alias in the 2006 AOP Certification. The requirements specific to 200W P-296SX-001 are found in AOP Table 1.5 - Process and Emission Units Exceeding Insignificant Emission Unit Threshold, Excluding Combustion Process.

Ecology Approval Order DE00NWP-002, Revision 1, issued on 6/29/06, was not incorporated into the AOP until the Renewal became effective on 1/1/2007. Therefore, it would not be subject to the annual AOP certification process for CY 2006. It will included in the next annual certification report. The CY 2006 certification report addresses the original DE00NWP-002, Revision 0 until it was superseded on 6/29/06.

Please call if you have any additional questions or if we need to discuss further.

#### Thanks!

Mary-Maria Jarvis, DOE-RL

Environmental Services (509) 376-2256 Hanford Area Pager 85-6328 FAX (509) 372-2610

Mary\_F\_Jarvis@RL.GOV

From: Sent:

Hendrickson, Douglas (ECY) [mailto:dohe461@ecy.wa.gov]

To:

Tuesday, October 16, 2007 10:22 AM

Jarvis, Mary F

Beam, Thomas G; Wang, Oliver S; Schmidt, John W (DOH)

Subject:

**AOP Comp Certification Clarifications** 

#### Mary:

Discussion at the last RATSI meeting included clarifications regarding Appendix A of DOE-RL-2007-04 (Certification report for 2006):

#### The clarifications I seek are:

Clarification meeting/correspondence is suggested to unify approach to certification statements (e.g. various facilities would alternately claim either Continuous compliance or Not Applicable for a facility which did not operate). One standard set of approaches is recommended. Facility certifications to clarify are listed in Table 2.

Table 2: Facilities for Which Certification Claims Should be Clarified		
NOC Permit	Descriptor	
97NM-551	N1724K 001 Maintenance Shop	
DE00NWP-001	200 Area Diffuse/Fugitive - Tank Farms	
DE98NWP-005	P-296P033-001 & P296P034-001 Rotary Mode Core Sampling	
	W-PORTEX 020, 024, and 025 Portable Exhauster for Use on SSTs	
DE98NWP-006	during Saltwell Pumping, Rev. 2	
	NRA 241-C-106 Tank Sluicing Phase II	
DE01NWP-003	WTP Concrete Batch Plant	
NOC 93-3	P-2025E ETF	
	P-244CR 001	
94-07-01	P-296A042 001 AY/AZ Ventilation	
	P-296AN 001	
	P-296AP 001	
	P-296AW 001	
	296-S-15	
DE00NWP-002	J-CWC 001	
DE03NWP-001	P-241U107-001, P-241S102-001, P-241S112-001	
DE01NWP-002	P-2706T 001	
•	P-296P028-001	
Letter 7/13/92	S-296S021-001 222-S Laboratory Hot Cell Expansion	
DE98NWP-003	331C-01-V (EP-305B-02V)	
	E-900 001	
	E-900 002	
	E-900 003	
DE02NWP-001	Emergency Diesel Generators	
	Hanford Site Asbestos Landfill	

Specifically, each of these have conditions certified which involve emissions limitations or control requirements (e.g. RACT) which have been certified to be "Not Applicable" or "Continuous" inappropriately or administrative requirements which are inappropriately certified to be in "continuous" compliance.

- Regardless of whether the unit operated, the conditions involving emissions limits and control requirements ARE applicable unless specifically defined as inapplicable (e.g. SO2 from non-combustion unit, fugitives from a stack).
- The CDM may readily be stated as "unit did not operate" if that is the case.
- Many of these have conditions which are administrative (e.g. file a notice). If the actions which
  trigger such a requirement did not exist then "Not Applicable" is correct, but these have frequently
  been certified as "Continuous."

Examples of appropriate discretion in defining Continuous vs Not Applicable (based upon not operating) include:

NWP-96-1	E-282ED 001
NWP-96-1	E-282WD 001
97NM-137	P-340NTEX-001, Tank Sludge Cleanout

Ecology has read and interpreted these certifications to be compliant in view of the operating status or CDM. However, we want to work toward a consistent understanding of applicable standards and therefore of the value of the certification statements.

I know that you will want to digest this more. The likely path to closure will be that when we write a letter closing our review of the compliance certification we will give guidance for "how-to" certify in these conditions.

Two other items - if you could look into:

A-43 to A-44	296-S-15 is certified, reported to have been part of the AOP since 2001, but was not reported in the last two certification reports
A-47	J-CWC-001: Certification is to conditions prior to permit revision June 29, 2006. Review assessments of emissions to current permit. (incl in Table 2)

Let me know when/how to discuss and whether the closeout letter remains the best path for the top set of items.

Doug Hendrickson, P.E.

Nuclear Waste Program
Washington State Department of Ecology
509.372.7983
(c) 509.531.0727

# Attachment 4 10-ESQ-305

Guidance Document for Providing Input to the CY 2007 Hanford Site Air Operating Permit Annual Compliance Certification Report,
Revision 1

# GUIDANCE DOCUMENT FOR PROVIDING INPUT TO THE CY 2007 HANFORD SITE AIR OPERATING PERMIT ANNUAL COMPLIANCE CERTIFICATION REPORT Revision 1

Environmental Policy, Monitoring & Reporting Fluor Hanford, Inc.

April 2008

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The purpose of this document is to provide general guidance for Site Contractors to provide input to the FH AOP Team to prepare the Hanford Site Air Operating Permit (AOP) Annual Certification Report.

#### 1.0 BACKGROUND

#### 1.1 What is the Hanford Site AOP Annual Compliance Certification Report?

The purpose of the report is to certify compliance with all relevant terms and conditions in the AOP during the reporting period.

The report satisfies the WAC 173-401-630 (5)(a) and the AOP Standard Terms and General Conditions 4.3.4 requirements to do so annually.

The report is a compilation of all the emission unit-specific terms, conditions, and requirements in the AOP and their corresponding compliance status, including the method(s) used to demonstrate that compliance. The compliance status is determined by records, procedures, and other information available at the time the certification is made. Each Hanford Site Contractor is responsible for certifying the compliance status for air emission sources under their control.

The final report is certified by a Responsible Official (as defined in WAC 173-401-200) in accordance with WAC 173-401-520 for truth, accuracy, and completeness. The Department of Energy (DOE), Hanford Operations, as represented by the Richland Operations Office (RL) and the Office of River Protection (ORP), is the designated Permittee for the Hanford Site AOP. Therefore, the final report is certified jointly by the RL and ORP Managers for air emission sources under their respective control.

The report is used by the Authority to determine the compliance status of the Hanford source with the Hanford Site Air Operating Permit during the compliance reporting period.

#### 1.2 Recipients and Submittal Date of the Report

The final report will be submitted by DOE to the Washington Department of Ecology (Ecology), the Washington State Department of Health (WDOH), the Benton Clean Air Authority (BCAA), and the U.S. Environmental Protection Agency (EPA) Region 10 no later than July 31, 2008. Fluor Hanford Inc. will transmit the completed document to DOE, along with supporting certifications from each contractor, no later than June 30, 2008.

#### 1.3 Information Included and Not Included in the Report

The required report content is specified in the AOP Standard Terms and General Conditions Section 4.3.4, *Annual Compliance Certification*. The report must include the following information.

- a. Each emission unit-specific term or condition (i.e. requirement) listed in Attachments 1, 2, and 3, pursuant to the source's or emission unit's operational portion of CY 2007.
- b. The compliance status (continuous, intermittent or not applicable) of each term or condition. More specifics are discussed in Section 2.0.
- c. The method(s) used to determine the compliance status of the source for the reporting period. More specifics are discussed in Section 3.0.

- d. Such other facts as Ecology, WDOH, or BCAA may require to determine the compliance status of the source.
- e. Certification for truth, accuracy, and completeness by a Responsible Official (WAC 173-401-200(29).

The following are not subject to the annual compliance certification process and are not included in the report:

- f. Ecology-regulated insignificant emission units (IEUs) (discussed in AOP Attachment 1 Statement of Basis). Unless there were observed, documented, or known instances of non-compliance during the certification period.
- g. WDOH-regulated diffuse and fugitive emission units listed in AOP Attachment 2 Enclosure 2 Table 2-1. Certification of these requirements is satisfied by information submitted in the Annual NESHAP Radioactive Air Emissions Report.
- h. Emission unit-specific information (i.e. height, diameter, velocity, temperature, and operational status) listed in individual emission unit licenses in AOP Attachment 2. Certification of this information is satisfied by submittal of the Annual NESHAP Radioactive Air Emissions Report.

NOTE: Specifics to include or not include WDOH ALARACTs listed in AOP Attachment 2 Enclosure 3 and WDOH General Conditions listed in AOP Attachment 2 will be determined in an April 24, 2008 meeting with the Regulators or shortly there after.

#### 1.4 Certification Period and Inclusion Criteria for Relevant and Applicable Requirements

The compliance certification period is from January 1<sup>st</sup> through December 31<sup>st</sup> of each year. Individual requirements must meet two criteria before being included in the compliance certification period, and based on these two criteria will have an applicable certification time frame of their own.

- a. The requirement must be formally incorporated into the AOP within the certification period, AND
- b. The requirement must also be active during any portion of the certification period.

An active requirement is one that has not been superseded by a newly issued NOC, or a requirement that has not been made obsolete or irrelevant by submitting NOC or emission unit closure paperwork. If an NOC and/or approval order is superseded, the terms and conditions become irrelevant and cease to be an AOP applicable requirement from that date forward.

These nuances of the annual compliance process often create differences between the timeframes that facilities must comply with requirements from NOC approvals during day-to-day operations and the timeframes for which compliance must be certified for those same requirements. Some examples to illustrate these distinctions are provided below.

**EXAMPLE 1:** Ecology or WDOH issued an NOC approval effective sometime in CY 2006. The requirements from this approval were included in the AOP Renewal 1 issued effective January 1, 2007. The emission unit remained active/operational throughout CY 2007 and no subsequent changes were made to the requirements in the approval. These requirements would be subject to the annual compliance certification for all CY 2007.

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**EXAMPLE 2:** WDOH issued an emission unit license with ten (10) specific requirements on October 5, 2006. The AOP Renewal 1 issued effective January 1, 2007 included all 10 requirements of this license. In addition, WDOH approved an NOC modification short form on November 14, 2006 that revised the 3<sup>rd</sup> requirement, making the original one obsolete. The revised WDOH emission unit license reflecting the revised 3<sup>rd</sup> requirement was issued on May 18, 2007 and incorporated into the AOP on July 261, 2007. The compliance status for requirement #3 would be certified for the timeframe July 26, 2007 to December 31, 2007 because the original requirement was obsoleted November 14, 2006 and the revised requirement wasn't incorporated into the AOP until July 26, 2007. Compliance status for the other nine requirements would be certified for all of CY 2007.

**EXAMPLE 3:** The NOC approval order requirements for a pre-existing Ecology-regulated emission unit are included in the AOP Renewal 1 issued effective January 1, 2007. The emission unit is permanently deactivated on July 19, 2007 and a closure notice is submitted to Ecology on September 28, 2007. The emission unit is removed from the AOP on December 5, 2007. The compliance status for the NOC approval order requirements for this emission unit would be certified for the timeframe January 1, 2007 to September 28, 2007.

**EXAMPLE 4:** Ecology or WDOH issued an NOC approval effective sometime prior to CY 2007. The requirements from this approval were included in the AOP Renewal 1 issued effective January 1, 2007. A revised approval is issued effective July 31, 2007 that obsoletes the original approval. The requirements of the revised approval are incorporated into the AOP on December 5, 2007. The compliance status for requirements in the AOP from the original approval would be certified for the timeframe January 1, 2007 to July 31, 2007. The compliance status for requirements in the AOP from the revised approval would be certified for the timeframe December 5, 2007 to December 31, 2007.

#### 2.0 DETERMINING COMPLIANCE STATUS

The term 'compliance status' refers to the degree of compliance to a particular requirement over the entire reporting period rather than just the current status of compliance at the time of certification. There are only three options used in the certification report; continuous, intermittent and NA (not applicable).

Following their verification of the CY 2006 Certification Report, Ecology requested that future reports use a more consistent and unified approach to the use of compliance status terms "NA" and "Continuous" and have provided the following clarification which has been incorporated into the following sections.

- Requirements involving emissions limits, control equipment, and monitoring are generally always applicable unless specifically defined as inapplicable (e.g. SO2 from non-combustion units or fugitive emissions from a stack), or required by a triggering event that did not occur.
- For occasions when a requirement is triggered by a specific event (e.g., set up a portable CAM if a specific contamination level is reached, or notify DOH if a specified contamination level is encountered) and that event did not occur, the requirement is not applicable and therefore the compliance status would be Not Applicable.
- For occasions when the emission unit has not been constructed yet, the requirements are not applicable, and therefore the compliance status would be Not Applicable.
- For occasions when an emission unit did not operate during the reporting period the emissions would be zero and therefore fall within the required limit so the compliance status would be Continuous.

CDM: Field Interviews.

Comment: No activities were conducted requiring the use of the NOC during the year.

### 2.1 Continuous Compliance Status

The WAC 173-401-200(7) definition:

"Continuous compliance means collection of all monitoring data required by the permit under the data collection frequency required by the permit, with no deviations, and no other information that indicates deviations, except for unavoidable excess emissions or other operating conditions during which compliance is not required. Monitoring data includes information from instrumental (e.g., CEMS, COMS, or parameter monitors) and noninstrumental (e.g., visual observation, inspection, recordkeeping) forms of monitoring."

Compliance is considered continuous if there are no observed, documented, or known instances of noncompliance.

#### 2.1.1 For Monitoring Requirements

For monitoring requirements, continuous compliance generally means the collection of all monitoring data required by the permit under the data collection frequency specified by the permit throughout the reporting period.

The EPA provides the following related guidance on continuous monitoring in the <u>Guidance on Implementing the Radionuclide NESHAP</u>:

"The air at the point of measurement shall be continuously sampled for collection of radionuclides – What represents continuous sampling? The requirements for continuous sampling will be considered satisfied when an 80 percent QA completeness requirement is met. That is, the time the sampler is not in satisfactory operation due to malfunctions, filter or sample changes, maintenance, calibration, etc., cannot exceed 20 percent of the sampling period."

#### 2.1.2 For Abatement Control Technology Requirements

Compliance is considered continuous if the abatement control equipment was physically in place, absent any shutdown that lasted long enough to lose confinement, and the specified operational configuration was maintained when the system was operating. The notes in the AOP Attachment 2 "Additional Description/Conditions" fields, such as "In parallel, one operating, two back-up" are part of the required operational configuration for that particular abatement control technology.

### 2.1.3 Can Continuous Compliance Be Certified Using Periodic Monitoring?

Yes. AOPs are approved on the basis that the requirements in the Permit are sufficient to ensure continuous compliance. Ecology, WDOH, and EPA Region 10 determined the monitoring provisions, contained in the final AOP, to be sufficient for continuous compliance assurance. Therefore, a certification of 'Continuous Compliance' with respect to an emission limitation or requirement can be made even though the AOP requires only periodic monitoring.

#### 2.2 Intermittent Compliance Status

Compliance is considered intermittent if the facility is known to have been out of compliance with an applicable condition or limitation at any time during the reporting period or the required monitoring was

not performed or recorded. Also note that non-compliances or deviations have been previously reported in the appropriate AOP Semiannual Reports for the same calendar year.

All instances of noncompliance and deviation from AOP requirements must be documented in the comment field of the certification report. Generally, documentation takes the form of deviation reports, occurrence reports, etc. A deviation is not necessarily a violation. The agencies determine if a violation occurred based on all the available information.

### 2.3 Not Applicable Compliance Status

Compliance status is not applicable if the corresponding requirement is not applicable.

Common occasions that compliance status would be Not Applicable are:

- The requirement is triggered by a specific event (e.g., set up a portable CAM if a specific contamination level is reached, notify DOH if a specified contamination level is encountered, or if the Guzzler is used comply with its NOC) and that event did not occur.
- The emission unit has not been constructed yet.
- If there is no action required by the Permittee or if there is a more restrictive AOP requirement for a specific emission unit.
- A condition that conveys a right, that is a historical summary or statement of fact, that pertains to actions to be completed in the future, or that pertain to actions required of the regulatory agencies.

**NOTE:** During the AOP Renewal 1 process Ecology and WDOH have determined that the Permittee need not certify compliance with this type of permit condition and these types of conditions have been moved to the General Conditions sections of the AOP.

### 3.0 COMPLIANCE DETERMINATION METHODS

The compliance determination method is the basis and/or information used to demonstrate compliance to a particular requirement.

In general, describe the action taken to verify compliance to the requirement. Such actions could include, but are not limited to:

- Reasonable inquiry of persons directly responsible for the emission unit (e.g., Cognizant Engineer, Environmental Compliance Officer, Subject Matter Expert, etc.).
- Field walk downs.
- Review of monitoring logs.
- Review of facility records.
- Review of data in ABCASH.
- Specified monitoring.
- Reference to other published regulatory reports.
- Reference to company QA programs.
- Reference to site wide monitoring programs.

### 3.1 Does the Permittee have to develop and implement new processes and procedures to determine compliance with terms and conditions of the AOP?

No. However, processes and procedures should be in place to ensure compliance with AOP conditions.

#### 3.2 What is the basis for certifying compliance with Near-Facility monitoring requirements?

Fluor Hanford (FH)-Monitoring and Reporting provides a certification for the near-facility monitoring requirements in the AOP. All contractors, except Pacific Northwest National Laboratory (PNNL), can verify that any required Near-Facility monitoring was conducted by querying the automated bar coding of air samples at Hanford (ABCASH) electronic systems. PNNL operates, and is responsible for, their own environmental monitoring program.

### 3.3 What is the basis for certifying compliance with the requirement to *report* all measured or calculated emissions annually [WAC 246-247-080(3)]?

Generally, the Annual Radioactive Air Emissions Report for the reporting period satisfies these requirements. If you have supplied the requested information to assist in the completion of this report, consider that you are in Continuous compliance with these conditions. The final radioactive air emissions report is not available until June 30 which is several weeks after management's AOP certification is due.

#### 3.4 What is the basis for certifying compliance with emission limits?

Compliance with limits on emission rates for radionuclides identified in emission unit terms and conditions, as specified by WAC 246-247-040(5), is required for minor emission units listed in AOP Attachment 2 and is satisfied by the information submitted in the Annual Radionuclide Air Emissions Report for the reporting period.

#### 3.5 What is the basis for certifying compliance with monitoring and testing?

Compliance with monitoring and testing procedures for emission units listed in AOP Attachment 2 is generally satisfied by the applicable company NESHAP quality assurance project plan:

#### Method 2, Appendix A:

**CDM:** Cite specific facility procedure.

```
Method 114, Appendix B;
40 CFR 61.93(b)(2)(ii);
40 CFR 61.93(c)(2)(i);
40 CFR 61.93(c)(4)(e);
40 CFR 61.93(b)(4)(i);
WAC 246-247-075(2);
WAC 246-247-075(3):
```

**CDM:** NESHAP Quality Assurance Project Plan for Radioactive Air Emissions (HNF-EP-0528, latest revision), or your applicable company plan .

#### 3.5.1 Compliance with WAC 246-247-075

There is a WDOH requirement in their newer NOC approvals up front in the Emission Unit Monitoring and Sampling Requirements section that says "Applicable requirements: Monitoring, Testing and Quality Assurance WAC 246-247-075"

This requirement refers globally to all -075 subparagraphs, some of which also may be called out in the Conditions and Limitations section; therefore, the following is the suggested strategy.

List and address the subparagraphs that ARE NOT called out in a specific condition up front with the Emission Unit requirement and make a statement that the remaining applicable subparagraphs will be addressed with the specific condition and then address those subparagraphs with their corresponding conditions. Use the following statement to refer to the remaining applicable subparagraphs: "See conditions below for compliance status with the remaining applicable paragraphs of WAC 246-247-075."

Use the following guidance for response to each subparagraph, as applicable:

WAC 246-247-075(1) - 40 CFR 61 monitoring and QA requirements are applicable by reference. DOE/RL-2007-01, Revision 0, "Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2006" and the "NESHAP Quality Assurance Project Plan for Radioactive Air Emissions" (HNF-EP-0528), or other applicable company QA plan, satisfy WAC 246-247-075(1).

<u>WAC 246-247-075(2)</u> - continuous monitoring (most major stacks) - existing CDM for "Required Sampling" satisfies this requirement.

WAC 246-247-075(3) - PTE < 0.1 mrem/yr. (minor stacks) - existing CDM for "Required Sampling" satisfies this requirement.

<u>WAC 246-247-075(4)</u> - for approved alternative monitoring - existing CDM for "Required Sampling" satisfies this requirement. No additional text is required.

WAC 246-247-075(5) and (7) - inapplicable to Hanford

WAC 246-247-075(6) - Cite "NESHAP Quality Assurance Project Plan for Radioactive Air Emissions" (HNF-EP-0528), or other applicable company QA plan.

WAC 246-247-075(8) – The Near Facility Monitoring Program generally satisfies this requirement.

WAC 246-247-075(9) & (10) - inapplicable as these are WDOH actions

WAC 246-247-075(11) - Applicable to planning. Not applicable once approval is issued.

<u>WAC 246-247-075(12)</u> - Cite training records or other documents (e.g., procedures, etc.) that verify personnel associated with the emission unit are trained in the use and maintenance of emission control and monitoring systems, and in the performance of associated test and emergency response procedures.

WAC 246-247-075(13) - Cite HNF-EP-0528: "NESHAP Quality Assurance Project Plan for Radionuclide Air Emissions", or other applicable company QA plan.

Page 7 of 8

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### APPENDIX A

#### INSTRUCTIONS FOR ACCESSING THE ON-LINE INPUT SCREENS

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APP A-ii

April 24, 2008

#### INSTRUCTIONS FOR ACCESSING THE ON-LINE INPUT SCREENS

The Hanford Site AOP *Annual Compliance Certification Report* is prepared as an electronic report generated from a data collection application located on the Hanford Intranet. The internet application extracts requirements from the AOP database to populate the individual certification statements contained in the report. The report generator displays all of the facility specific, emission unit specific and NOC specific requirements that were incorporated into the AOP and active (*i.e.*, were not obsolete or irrelevant) during CY 2007. Hanford Site contractors use this intranet-based data collection and report generator tool to simplify the process, increase efficiency and promote consistency in the compliance demonstration method responses.

To begin the process, take one of two paths.

- Either go directly to the AOP Home Page at <a href="http://www7.rl.gov/aop/">http://www7.rl.gov/aop/</a> and then start with Step 6 below; OR
- Start with Step 1 below and follow the instructions.
- 1. From the DOE Hanford Intranet home page, click on Fluor Hanford Inc (Figure 1).

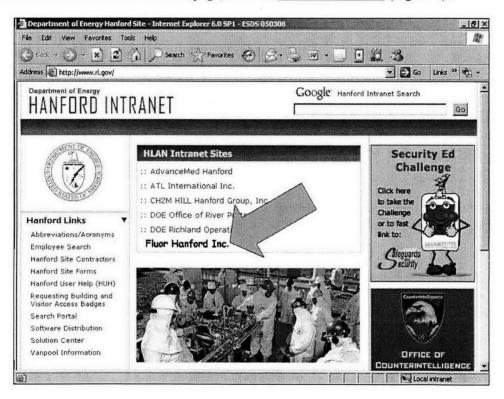


Figure A-1. DOE Hanford Intranet Home Page.

2. Click on Environmental, Safety, Health & Quality and continue with Step 3 OR as an alternative, type "AOP" into the Shortcut URL box and select "GO". This will take you directly to the AOP Home Page and you can skip to Step 6 (Figure 2).



Figure A-2. Fluor Hanford Page.

3. Click on Our Organization on the left menu, then Environmental Protection (Figure 3).



Figure A-3. Fluor Hanford Functional Organizations Page.

4. Click on <u>AIR / AOP</u> on the left menu, then <u>Permit and Licenses</u> (Figure 4).



Figure A-4. Fluor Hanford Environmental Protection Page

5. Click on AOP Website (Figure 5).

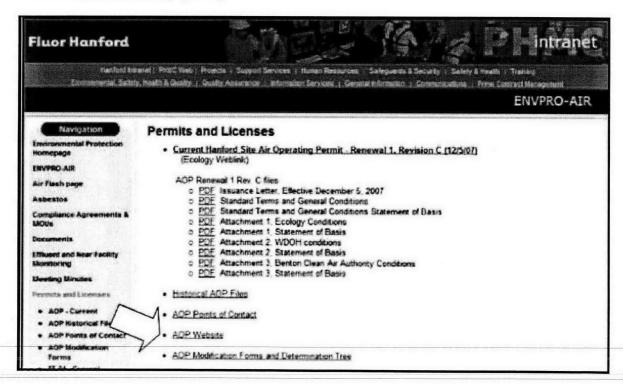


Figure A-5. Fluor Hanford EP Permits and Licenses Page.

#### 6. Click on Annual Certification Input (Figure 6).

NOTE: If you do not see the <u>Annual Certification Input</u> link, please contact Nancy Homan or Robert Anderson for access. The <u>AOP Admin</u> link is only visible to system administrators.

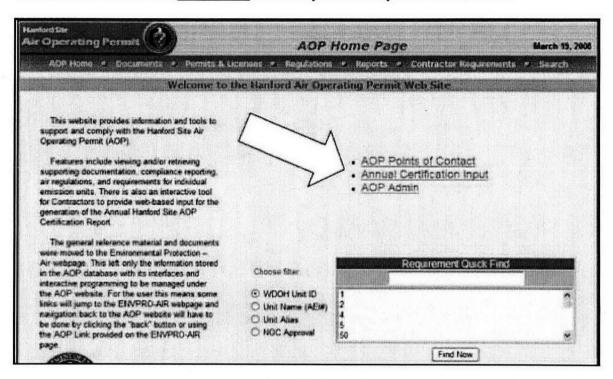


Figure A-6. AOP Home Page.

7. The initial display will show a list of WDOH-regulated emission units sorted by Responsible Contractor (Figure 7). To view a list of Ecology-regulated emission units sorted by Responsible Contractor, click on "show me <u>Ecology"</u> (Figure 8).

Locate the contractor of interest, and click on the "+" or the contractor name to reveal the listing of individual emission units assigned to that contractor (as illustrated in Figures 7 and 8 for BNI emission units).

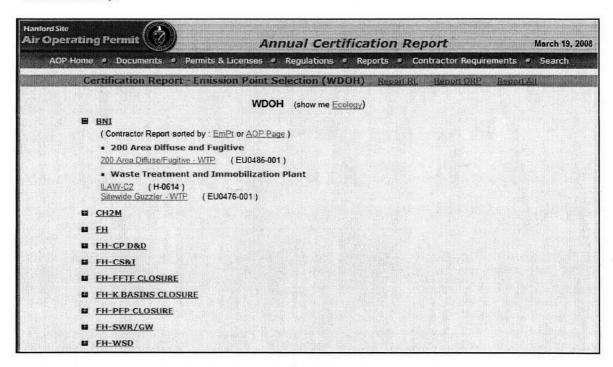


Figure A-7. Annual Certification Report Page – WDOH Emission Units Sorted by Contractor.

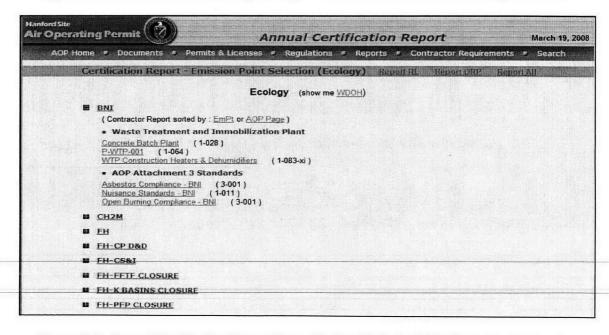


Figure A-8. Annual Certification Report Page - Ecology Emission Units Sorted by Contractor.

8. Locate the desired emission unit, click the link, and the requirements for that emission unit will be displayed on the screen (Figure 9).

NOTE: For WDOH-regulated emission units, the initial display only shows the Emission Point requirements (i.e. abatement technology, sampling, monitoring). Click on <u>Input NOC Compliance Methods</u> to bring up individual license requirements.

NOTE: For Ecology-regulated emission units, the initial display shows all requirements (including those from individual NOC approval orders).

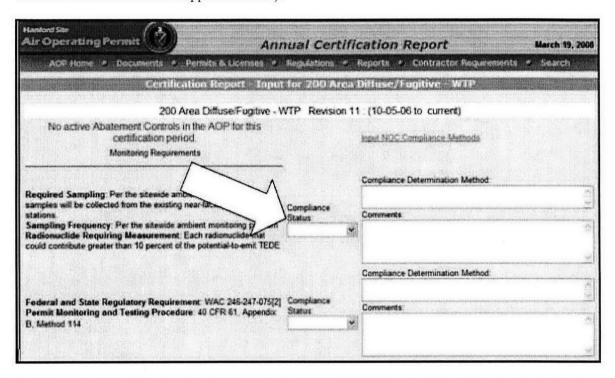


Figure A-9. Annual Certification Report Input Screen - WTP 200 Area Diffuse/Fugitive Emission Unit.

9. For each listed requirement, identify and select the appropriate **Compliance Status** option (Continuous, Intermittent, or Not Applicable). In the **Compliance Determination Method** box, describe the information and/or procedures/processes used to verify or demonstrate compliance with the listed requirement. The **Comments** box is used to provide additional clarification of the **Compliance Determination Method** information. Refer to Sections 2 and 3 of this document, along with Appendices B through D, for additional guidance on completing the data entry.

NOTE: Access to perform the data entry process is granted to specified individuals on a contractor and/or project-specific basis. For example, designated CH2M personnel can only enter information for emission units under CH2M control; and designated PFP personnel will only be able to enter information for PFP emission units.

NOTE: If you are unable to select the dropdown box or enter information into the text boxes, you have not been granted access to perform this data entry process. Contact Nancy Homan or Robert Anderson to request access.

10. **IMPORTANT**: After the desired information has been entered, you must click on the **Save** button at the end of the section (Figures 10, 11, and 12) or your data will be lost. <u>Do not</u> attempt to 'Save' using the tool bar or drop down file menu, or your data will be lost.

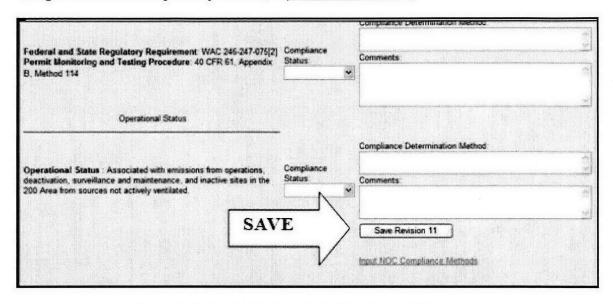


Figure A-10. Saving Emission Point Requirement Responses.

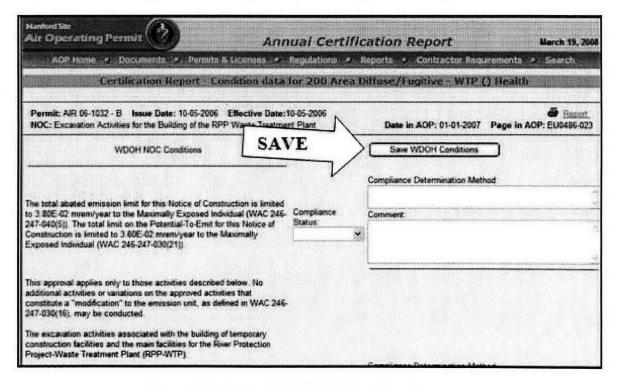


Figure A-11. Saving WDOH NOC Condition Responses.

Condition: Emission Control Monitors Emission equipment control monitors shall include but not be lemined to the following A. Bag-house - None required if there are no visible emissions per section 1.A. of the APPROVAL CONDITIONS and maintenance records indicate proper maintenance practices and schedules. Model ID: Not applicable.	Compliance Status	Compliance Determination Method
EPA Test Method: Not specified. EPA Test Method Frequency: Not applicable. Periodic Monitoring: Recordivering. Required Records: Surveillance checkists, bag- house maintenance logs.  Condition: General Conditions.		
A Visible Emissions No visible emissions shall be allowed beyond 100 yards of source. During periods of high winds, an assessment shall be made to suspend operations or initiate a more comprehensive plant watering scheme.  Model ID: Not applicable.	Compliance Status	Compliance Determination Method
EPA Test Method: Not specified EPA Test Method Frequency: Not applicable. Periodic Monitoring: Visible Emission Surveys. Required Records: Results of visible emission surveys.		Same Ecology Constitions SAVE

Figure A-12. Saving Ecology Condition Responses.

- 11. Repeat Steps 8 through 10 for all assigned WDOH and Ecology-regulated emission units.
  - NOTE: Individual emission units do not always have both WDOH and Ecology requirements.
- 12. When all data entry has been completed and saved for an emission unit, a hard copy of your report input may be printed or saved to file for record keeping and filing purposes by clicking on the <u>View Report</u> link from any of the data input screens (Figure 13).

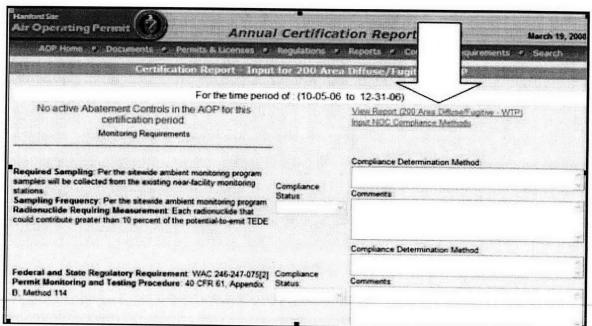


Figure A-13. Printing Hard Copy of Report Input.

#### **APPENDIX B**

### **EXAMPLE CERTIFICATION REPORTS FOR**

THE 222-S LABORATORY (WDOH)
AND
THE 296-A-42 STACK (ECOLOGY)

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#### (200W) S-296S021-001

WDOH Emission Unit ID: 254 Page in AOP: EU0254-001

### WDOH Emission Point Requirements

Requirement	Compliance Status	Compliance Determination Method
For the time period of: (01-0	1-07 to 12-31-	-07)
Zone or Area: Abatement Technology: HEPA Required Units: 3 Add'l Description: In series for both the primary and backup exhaust systems (222-S Lab Hot Cells)	Continuous	CDM: Field interviews and asbuilt drawings. Comment: H-2-46710, H-2-46514, H-2-81072, and H-2-830965.
Zone or Area: Abatement Technology: HEPA Required Units: 1 Add'l Description: For both primary and backup exhaust systems (222-S Lab Complex)	Continuous	CDM: Field interviews and asbuilt drawings. Comment: H-2-46710, H-2-46514, H-2-81072, and H-2-830965.
Zone or Area: Abatement Technology: Fan Required Units: 3 Add'l Description: Primary exhaust operated in parallel, serves both hot cell addition & main lab.	Continuous	CDM: Field interviews and asbuilt drawings. Comment: H-2-46710, H-2-46514, H-2-81072, and H-2-830965.
Zone or Area: Abatement Technology: Fan Required Units: 1 Add'l Description: Backup exhaust operates independently or in parallel with primary exhaust.	Continuous	CDM: Field interviews and asbuilt drawings. Comment: H-2-46710, H-2-46514, H-2-81072, and H-2-830965.
Required Sampling: Record Sample Sampling Frequency: Continuous Radionuclide Requiring Measurement: Each radionuclide that could contribute greater than 10% of the potential TEDE.	Continuous	CDM: ABCASH program, CH2M HILL notification procedure, and notification logbook.  Comment: ABCASH EDP code number S289. Record sampler shut down once during the reporting period; reported per the CH2M HILL notification procedure.
Federal and State Regulatory Requirement: 40 CFR 61.93 (b)(4)(i)& WAC 246-247-075(2)  Permit Monitoring and Testing Procedure: 40 CFR 61, Appendix B Method 114	Continuous	CDM: CH2M HILL NESHAP quality assurance program.  Comment: None

Permit:AIR 06-1005 Issue Date:10-05-06 Effective Date:10-05-06 Obsolete Date: 10-30-07

NOC: 222-S Lab Hot Cell Expansion

WDOH NOC ID: 637 Date In AOP: 01-01	-07 Page in A	<b>OP:</b> EU0254-001
Requirement	Compliance Status	Compliance Determination Method
The total abated emission limit for this Notice of Construction is limited to 6.60E-03 mrem/year to the Maximally Exposed Individual (WAC 246-247-040(5)). The total limit on the Potential-To-Emit for Notice of Construction is limited to 6.00E-02 mrem/year to the Maximally Exposed Individual (WAC 246-247-030(21)).	Continuous	CDM: The annual "Radionuclide Air Emissions Report" for the Hanford Site. Comment: None
This approval applies only to those activities described below. No additional activities or variations on the approved activities that constitute a "modification" to the emission unit, as defined in WAC 246-247-030(16), may be conducted.  The Environmental Hot Cell Expansion to provide a new addition to the 222-S Laboratory. This expansion will provide a seven compartment hot cell to support the increased demand for analytical services.  Emissions from the hot cell will be exhausted through the existing stack at the 222-S Facility (registered stack number 296-S-21). Approximately 1200 cubic feet per minute will be emitted from the hot cell. Prior to being emitted to the atmosphere, the hot cell exhaust shall pass through two sets of existing High-Efficiency Particulate Air (HEPA) Filters (double HEPAs at both the 222-SC and 222-SB Facilities), in addition to one of the three new single-stage HEPA filters adjoining the hot cell. HEPA Filters are tested in place to ensure that they remove at least 99.5 percent of particles ranging in size from 0.1 micron to 3.0 microns, with a mean particle size of 0.5 micron.  The hot cell will examine both solid and liquid samples; approximately 43 samples/month will be liquid. Each solid sample will weigh up to 625 g, with a maximum specific gravity of 5.0. Each liquid sample will be approximately 125 ml. It was assumed that the specific gravity would be 2.0. Each of the samples (both liquid and solid) will have a maximum radionuclide concentration of 2000 uCi/g Sr-90 and 1000 uCi/g Cs-137. Based on these assumptions, the annual solid inventory for the hot cell is 645 Ci Sr-90 and 322.5 Ci Cs-137, and the annual liquid inventory is 72 Ci Sr-90 and 36 Ci Cs-137.	Continuous	CDM: Field interviews, CH2M HILL work planning/controls/documents, and procedures. Comment: None
The Annual Possession Quantity is limited to the following radionuclides (Curies/year):  Cs-137 3.59E+02   Sr-90 7.17E+02	Continuous	CDM: Field interviews and WDOH approved logs for APC tracking. Comment: None

Permit:AIR 07-1021 Issue Date:10-30-07 Effective Date:10-30-07 NOC: 222-S Lab Hot Cell Expansion WDOH NOC ID: 637 Date In AOP: 12-05-07 Page in AOP: EU0254-001				
Requirement	Compliance Status	Compliance Determination Method		
The total abated emission limit for this Notice of Construction is limited to 6.60E-03 mrem/year to the Maximally Exposed Individual (WAC 246-247-040(5)). The total limit on the Potential-To-Emit for Notice of Construction is limited to 6.00E-02 mrem/year to the Maximally Exposed Individual (WAC 246-247-030(21)).	Continuous	CDM: The annual "Radionuclide Air Emissions Report" for the Hanford Site. Comment: None		
This approval applies only to those activities described below. No additional activities or variations on the approved activities that constitute a "modification" to the emission unit, as defined in WAC 246-247-030(16), may be conducted.				
The Environmental Hot Cell Expansion to provide a new addition to the 222-S Laboratory. This expansion will provide a seven compartment hot cell to support the increased demand for analytical services.				
Emissions from the hot cell will be exhausted through the existing stack at the 222-S Facility (registered stack number 296-S-21). Approximately 1200 cubic feet per minute will be emitted from the hot cell. Prior to being emitted to the atmosphere, the hot cell exhaust shall pass through two sets of existing High-Efficiency Particulate Air (HEPA) Filters (HEPAs at both the 222-SC and 222-SB Facilities), in addition to one of the three new single-stage HEPA filters adjoining the hot cell. HEPA Filters are tested in place to ensure that they remove at least 99.5 percent of particles ranging in size from 0.1 micron to 3.0 microns, with a mean particle size of 0.5 micron.	Continuous	CDM: Field interviews, CH2M HILL work planning/controls/documents, and procedures. Comment: None		
The hot cell will examine both solid and liquid samples; approximately 43 samples/month will be solids, and approximately 12 samples/month will be liquid. Each solid sample will weigh up to 625 g, with a maximum specific gravity of 5.0. Each liquid sample will be approximately 125 ml. It was assumed that the specific gravity would be 2.0. Each of the samples (both liquid and solid) will have a maximum radionuclide concentration of 2000 uCi/g Sr-90 and 1000 uCi/g Cs-137. Based on these assumptions, the annual solid inventory for the hot cell is 645 Ci Sr-90 and 322.5 Ci Cs-137, and the annual liquid inventory is 72 Ci Sr-90 and 36 Ci Cs-137.				
The Annual Possession Quantity is limited to the following radionuclides (Curies/year):  Cs-137 3.59E+02   Sr-90  7.17E+02	Continuous	CDM: Field interviews and WDOH approved logs for APQ tracking. Comment: None		

(200E) P-296A042-001 Page in AOP: 1-058

Permit: NOC 94-07-01 Issue Date: 12-22-97 Date In AOP: 07-02-01

NOC: AY and AZ Tank Farms Ventilation Upgrades

Requirement	Compliance Status	Compliance Determination Method
Condition: VOC max emission limit, 50 ppm, measured as Total Organic Carbon.  Model ID: 4A.  EPA Test Method: EPA Method 25A or approved alternative.  EPA Test Method Frequency: Annually.  Periodic Monitoring: Recordkeeping and emission calculations.  Required Records: Organic vapor sampling data.	Continuous	CDM: Field interviews. Comment: None

NOC: AY and AZ Tank Farms Ventilation Upgrades

Requirement	Compliance Status	Compliance Determination Method
Condition: Ammonia, 0.05 lbs/hr. Model ID: 5. EPA Test Method: Field instruments, which may include Draeger Tubes. EPA Test Method Frequency: Annually. Periodic Monitoring: Recordkeeping and emission calculations. Required Records: 1. Stack flow measurements. 2. Record field instrument or Draeger Tube ammonia concentrations.	Continuous	CDM: Field interviews, sampling activity, CH2M HILL notification procedure and notification logbook.  Comment: An unavoidable upset condition occurred resulting in the release of Ammonia emissions in excess of 0.05 lbs/hr. It was determined to be an excusable excess emission under the provision of WAC 173-400-107(6)(c).

Permit: AOP Table 1.5 EUs Exceeding Threshold Issue Date: 01-01-07 Date In AOP: 01-01-07

NOC: AOP Table 1.5 Emission Units Exceeding Insignificant EU Threshold

Requirement	Compliance Status	Compliance Determination Method
Condition: WAC 173-400-040(1) 20% Opacity. Prohibits visible emissions exceeding 20% opacity for more than 3 minutes in any 1 hour of an air contaminant from any emissions unit or within a reasonable distance of the emission unit except for scheduled soot blowing/grate cleaning or due to documented water.  Model ID: Not applicable. EPA Test Method: EPA Method 9. EPA Test Method Frequency: Not applicable. Periodic Monitoring: Units with HEPA filtration: Section 2.1 Tier 3. Required Records:	Continuous	CDM: Abatement control technology was maintained for emission units 296-A-42 (EU ID 93) as required in AOP Attachment 2. Comment: None

Condition: WAC 173-400-040(6) 1,000 ppm SO2 @ 7% O2 on a dry basis. Prohibits emission of a gas containing sulfur dioxide from any emissions unit in excess of 1,000 ppm of a dry basis, corrected to 7% oxygen for combustion sources, and based on the average of any 60 consecutive minutes.  Model ID: Not applicable. EPA Test Method: EPA Method 6 or 6C of 40 CFR 60, App.A. EPA Test Method Frequency: Not applicable. Periodic Monitoring: Section 2.7, Tier 2. Ecology has determined, based on process knowledge, that these emission units do not emit significant levels of SO2. The permittee annually shall certify that the processes have not been modified to increase SO2 emissions and no SO2 monitoring is required. Required Records:	Continuous	CDM: The process has not been modified to increase SO2 emissions. Comment: None
Condition: WAC 173-400-040, 1st Paragraph [Table 1.2 General Standard] Reasonable available control technology (RACT). Model ID: Not applicable. EPA Test Method: Not specified. EPA Test Method Frequency: Not applicable. Periodic Monitoring: Permit terms considered RACT. Required Records:	Continuous	CDM: Field interviews. Permit terms are considered RACT. Comment: None

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APP B-6

### APPENDIX C

## EXAMPLE COMPLIANCE DETERMINATION LANGUAGE FOR COMMON WDOH CONDITIONS

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APP C-ii

Requirement	Compliance Status	Compliance Determination Method
The total abated emission limit for this Notice of Construction is limited to 3.90E-02 mrem/year to the Maximally Exposed Individual (WAC 246-247-040(5)). The total limit on the Potential-To-Emit for this Notice of Construction is limited to 7.51E+01 mrem/year to the Maximally Exposed Individual (WAC 246-247-030(21)).	"Continuous" or "Intermittent"	CDM: Abated: Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007.  Unabated: Verify that the release information used to determine unabated emissions in the NOC application has not increased.  Comment:
This approval applies only to those activities described below. No additional activities or variations on the approved activities that constitute a "modification" to the emission unit, as defined in WAC 246-247-030(16), may be conducted	"Continuous" if process description remains accurate, else "Intermittent"	CDM: Cite procedure that implements approval condition.  "Field interviews, CH2M HILL work planning/controls/documents, and procedures."  "Review of facility and procedure change documents as specified in administrative procedures."  Comment:
The Annual Possession Quantity is limited to the following radionuclides (Curies/year)	"Continuous" if basis for calculated APQ's remain as reported in NOC application, else "Intermittent"	CDM: Verify the basis for the APQ in the NOC Application.  Comment:
The facility must be able to demonstrate that it has a quality assurance program compatible with applicable national standards (WAC 246-247-075(6)).	"Continuous"	CDM: NESHAP Quality Assurance Project Plan for Radionuclide Air Emissions, HNF-EP-0528, latest revision. Or the applicable company NESHAP Quality Assurance Project Plan.  Comment:
The facility shall report all measured or calculated emissions annually (WAC 246-247-080(3)).	"Continuous"	CDM: Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007.  Comment:

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APP C-2

### APPENDIX D

### EXAMPLE COMPLIANCE DETERMINATION LANGUAGE FOR ECOLOGY GENERAL STANDARDS, ASBESTOS AND OPEN BURNING

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APP D-ii

Ecology General Standard	Compliance Status	Compliance Determination Method
Nuisance Standards (Table 1.2) - Sitewide I	Roll-up for Odoi	r, Concealment and Masking, Fallout, etc.
Req'mt Citation: WAC 173-400-040(2) Standard: Fallout: Prohibits emissions of particulate matter from any source to be deposited beyond the facility boundaries in sufficient quantity to interfere unreasonably with the use and enjoyment of the property upon which the material was deposited.  Periodic Monitoring: Recordkeeping of Complaint Investigation.	Continuous	CDM: No requests for complaint investigations were received from Ecology during the reporting period, as required by AOP Attachment 1 Section 2.2.  Comment:
Req'mt Citation: WAC 173-400-040(4) Standard: Odor: Requires any facility causing an odor which unreasonably interferes with another person's use and enjoyment of their property to use recognized good practices and procedures to reduce odors to a reasonable minimum. Periodic Monitoring: Recordkeeping of complaint investigations.	Continuous	CDM: No requests for complaint investigations were received from Ecology during the reporting period, as required by AOP Attachment 1 Section 2.2.  Comment:
Req'mt Citation: WAC 173-400-040(5) Standard: Emissions detrimental to persons or property: Prohibits emissions of any air contaminant from any source which is detrimental to the health, safety, or welfare of any person, or causes damage to property or business. Periodic Monitoring: Recordkeeping of complaint investigations.	Continuous	CDM: No requests for complaint investigations were received from Ecology during the reporting period, as required by AOP Attachment 1 Section 2.2.  Comment:
Req'mt Citation: WAC 173-400-040(7) Standard: Concealment and Masking: Prohibits the installation of use of any device or use of any means which conceals or masks an emission of an air contaminant which would otherwise violate any provision of WAC 173-400. Periodic Monitoring: Recordkeeping or complaint investigation.	Continuous	CDM: No requests for complaint investigations were received from Ecology during the reporting period, as required by AOP Attachment 1 Section 2.2.  Comment:
Other Ge	neral Condition	s from Table 1.2
Req'mt Citation: WAC 173-400-040(1) Standard: 20% Opacity: Prohibits visible emissions exceeding 20% opacity for more than 3 minutes in any 1 hour of an air contaminant from any emissions unit or within a reasonable distance of the emission unit except for scheduled soot blowing/grate cleaning or due to documented water.  Periodic Monitoring: Visible Emission Surveys Test Method: Ecology Method 9	Continuous	Emission Unit with HEPA (Ref. AOP Attachment 1, Section 2.1, Tier 3)  CDM: Abatement control technology was maintained as required in AOP Attachment 2, page 2-XXX.  Other Emission Units: (Ref. AOP Attachment 1, Section 2.1, Tier 1 and Tier 2)  Facility specific response for visible emission surveys.

Ecology General Standard	Compliance Status	Compliance Determination Method
		NOTE: Specific NOC approval conditions may supersede this requirement and CDM.
Req'mt Citation: WAC 173-400-040(6) Standard: 1000 ppm SO2 at 7% O2 on a dry basis: Prohibits emission of a gas containing sulfur dioxide from any emissions unit in excess of 1000 ppm of a dry basis, corrected to 7% oxygen for combustion sources, and based on the average of any period of 60 consecutive minutes.  Periodic Monitoring: For fossil-fuel combustion units: Recordkeeping or certification Test Method: EPA Method 6 or 6C of 40 CFR 60, App A	Continuous	non-combustion units: (Ref. AOP Attachment 1, Section 2.7, Tier 2)  CDM: The process has not been modified to increase SO2 emissions.  combustion units: (Ref. AOP Attachment 1, Section 2.7, Tier 1 and S.O.B. Section 3.1.1)  CDM: Vendor documentation verifies that fuel oil delivered contained < 0.5% S. Model 1 shows that diesel engines 2200 Hp or less can not exceed the 1000 ppm SO2 standard when using fuel with sulfur concentration < 0.5%.  NOTE: Specific NOC approval conditions may supersede this requirement and CDM.
Req'mt Citation: WAC 173-400-040(3)(a) Standard: Fugitive Emissions: The permittee shall take reasonable precautions to prevent the release of air contaminants from any emissions unit engaging in materials handling, construction, demolition, or any other operation which is a source of fugitive emissions.  Periodic Monitoring: Pre-job planning to determine reasonable control measures	Not Applicable	(Ref. AOP Attachment 1, Table 1.2 Footnote 2)  CDM: Emissions that pass through a stack are not sources of fugitive emissions [WAC 173-400-030(37)].  NOTE: From now on this requirement should not show up in the cert report for point source emission units because we apply this definition to filter it out. If it does show up, you can bring it to our attention to be removed (preferable) or respond with last year's CDM as provided above.
	Continuous	Facility specific verification of records, work packages, etc. that reasonable control measures were taken.
Req'mt Citation: WAC 173-400-040(8)(a) Standard: Fugitive Dust: Requires reasonable precautions be taken to prevent fugitive dust from becoming airborne and to minimize dust generation. Periodic Monitoring: Pre-job planning to determine reasonable control measures	Not Applicable	(Ref. AOP Attachment 1, Table 1.2 Footnote 2)  CDM: Emissions that pass through a stack are not sources of fugitive dust [WAC 173-400-030(36)].  NOTE: From now on this requirement should not show up in the cert report for point source emission units because we apply this definition to filter it out. If it does show up, you can bring it to our attention to be removed (preferable) or respond with last year's CDM as provided above.
	Continuous	Facility specific verification of records, work packages, etc. that reasonable control measures were taken.

APP D-2

Ecology General Standard	Compliance Status	Compliance Determination Method	
Req'mt Citation: WAC 173-400-040 1st para Standard: Reasonably available control technology (RACT) Periodic Monitoring: Permit terms considered RACT	Continuous	[For Emission Units with OR without NOC approvals. "permit terms" refers to either NOC or AOP terms]  (Ref. AOP Attachment 1, Table 1.2 Footnote 3)  CDM: Permit terms are considered RACT.  Complied with all permit conditions for this emission point.	
Sitewide Asbestos Compliance			
Condition: The permittee shall comply with the National Emission Standards for Hazardous Air Pollutants (NESHAP), 40 Code of Federal Regulations (CFR) Part 61, Subpart M. "National Emission Standard for Asbestos," and the Benton Clean Air Authority (BCAA) Regulation 1, Article 8, Asbestos.	Continuous	<ul> <li>CDM: Review of records and inquiry of persons responsible for the activity.</li> <li>Comment: (examples from last year)</li> <li>Projects are reviewed for asbestos requirements. Persons responsible for performing activities are qualified and certified as appropriate.</li> <li>Some asbestos abatement work performed by Hanford Contractors was located in areas being remediated pursuant to the Comprehensive Environmental Restoration Compensation and Liability Act (CERCLA). Actions taken pursuant to CERCLA are exempt from permitting and other administrative requirements.</li> <li>The WTP is a new facility under construction. Asbestos containing products were not used and no demolition or renovation activities subject to 40 CFR 61 Subpart M or BCAA, Regulation 1, Article 8, occurred during the reporting period.</li> </ul>	
Sitewide Open Burning Compliance			
Condition: The permittee shall comply with WAC 173-425 and BCAA Regulation 1, Article 5, "Open Burning". The Department of Energy, or contractors, shall request a special opening burning permit and obtain BCAA approval for open burning activities subject to the underlying applicable requirement.	Continuous	CDM: Review of records and inquiry of persons responsible for the activity.  Comment: (examples from last year)  Complied with Special Burning Permit No. 20060007. Also burned wind blown tumble weeds.	

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# Attachment 5 10-ESQ-305

Ecology letter from D. Hendrickson to D. A. Brockman, RL, and S. J. Olinger, ORP, "Hanford Operating Permit Annual (AOP) Compliance Certification Report," dated April 14, 2010.



### STATE OF WASHINGTON DEPARTMENT OF ECOLOGY

3100 Port of Benton Blvd • Richland, WA 99354 • (509) 372-7950

April 14, 2010

Mr. David A. Brockman, Manager Richland Operations Office United States Department of Energy P.O. Box 550, MSIN: A7-50 Richland, Washington 99352 Ms. Shirley J. Olinger, Manager Office of River Protection United States Department of Energy P.O. Box 450, MSIN: H6-60 Richland, Washington 99352

Re: Hanford Air Operating Permit Annual (AOP) Compliance Certification Report

Reference: "Hanford Site Air Operating Permit Annual Compliance Certification Report for the Period January 1, 2008 through December 31, 2008, DOE-RL-2009-03, Rev. 0, June 19, 2009"

Dear Mr. Brockman and Ms. Olinger:

This letter transmits acceptance from the Department of Ecology (Ecology) of your AOP compliance certification (reference). We accept it as a complete and appropriate statement of compliance of Hanford Site air emission sources regulated under Washington Administrative Code (WAC) 173-400, -401, -460, and WAC 246-247 for calendar year 2008 with one exception.

We inspected seventeen emission sources of the United States Department of Energy-Richland Operations (USDOE-RL) and USDOE-Office of River Protection (ORP) based upon compliance assertions and stated methods of compliance demonstration provided under your certification. Table 1 contains our inspection findings (enclosure 1).

The exception from full acceptance of your certification is identified in Table 2 (enclosure 2). You are required to complete the action identified within Table 2 in order to remediate the incorrect compliance status certification.

We are pleased with the level of coordination and cooperation achieved regarding these inspections. All information requested was available during or promptly following the inspections. We find the facilities subject to physical inspections during this review were in compliance with existing AOP and Notice of Construction Approval Order requirements.

Mr. Brockman and Ms. Olinger April 14, 2010 Page 2

Ecology, the Washington State Department of Health, and the Benton Clean Air Authority reviewed your 2008 AOP compliance certification (reference). We completed additional inspections and documentary review where necessary to verify your claims of compliance. As the permitting authority for AOP permit 00-05-006, Ecology hereby accepts all compliance certification statements within DOE/RL-2009-03, Revision 0 with the exception identified in Table 2.

If you have any questions, please contact me at 509-372-7983.

Sincerely,

Doug Hendrickson, P.E.

Lead Air Engineer

Nuclear Waste Program

dbm

Enclosures (2)

cc w/enc:

Don Dossett, EPA

Laurie Kral, EPA

Dennis Bowser, USDOE

Cliff Clark, USDOE

Mary Jarvis, USDOE

David Lauer, BCAA

Philip Piestrup, BNI

Patrick Weiher, JCI

Tom Beam, MSA

Jerry Cammann, MSA

Rodger Woodruff, PNNL

Jeffry Voogd, WRPS

Stuart Harris, CTUIR

Gabriel Bohnee, NPT

Russell Jim, YN

Susan Leckband, HAB

Ken Niles, ODOE

John Martell, Health

Administrative Record: AOP

Environmental Portal

Enclosure 1

11000	Table 1: Facilities Inspection List	
NOC Permit/ FF-01 Emissions Unit	Facility Description	Inspection Results
DE08NWP-002	Waste Treatment Plant (WTP) Paint and Blasting Booths	Compliant
DE02NWP-002, as amended	WTP/Marshalling Yard	Compliant
97NM-022	Canister Vacuum Drying Facility	Compliant
DE98NWP-003, as amended	331-C Gas Cylinder Management Process	Compliant
97NM-147	331 Life Sciences Building	Compliant
97NM-137	P-340NTEX 001	Compliant
	242-A Evaporator	Compliant
DE05NWP-001 R 1	AN/AW Ventilation	Compliant
DE07NWP-001 as amended	HAMMER	Compliant
EU 93	296-A-42, 241-AY/AZ TANK FARM	Compliant
EU 498	W-296P47, Portable Exhauster 241-C-106	Compliant
EU 254	S-296S021-001, 222-S Laboratory	Compliant
EU 361	EP-325-01-S, 325 Building Radiological Processing Laboratory	Compliant
EU 412	EP-331-01-V, 331 LIFE SCI LAB	Compliant
EU 314	P-291T001-001, T PLANT COMPLEX	Compliant
EU 393	P-291Z001-001, PLUTONIUM FINISHING PLANT	Compliant
EU 503	P-296Z007-001, PLUTONIUM FINISHING PLANT	Compliant

#### Enclosure 2

Table 2: Erratum and Action		
FF-01 Emissions Unit (Certification Reference page)	Discussion	Required Action
EU 486, License AIR 06-1060 titled "Operation of New Ventilation Systems in AN and AW Tank Farms". License condition #9 {The effluent monitoring and sampling system shall meet the requirements of ANSI N13.1-1999. A written technical basis document required by Section 4 of ANSI N13.1-1999 shall be provided to WDOH for review and approval.} (Page B-441)	Following review, it has been determined that this condition, certified to be in continuous compliance, has not been met.	Submit an erratum with your 2009 calendar year compliance certification identifying a correction to the compliance status of this unit as reported in your 2008 compliance certification.

# Attachment 6 10-ESQ-305

Nuclear Waste Program Hanford Air Operating Permit Compliance Checklist



### Nuclear Waste Program

### **Hanford Air Operating Permit Compliance Checklist**

TYPE OF VISIT: TO Opening Conference Site Tour:	ECHNICAL ASSISTANC Yes No Yes No C	Closing Conference: Yes No
Site Information		
Site Name: U.	S. Dept. of Energy O. Box 550, Richla	y, Hanford Site and WA, 99352
Facility:	200 Area Emi	issions (DST)
Facility Location:	Hanford 200E	& 200W
Facility Contact(s	·	Ashington River Protection Solutions, LLC Secret 7.33%.
Title(s);	Environmental	Compliance Officer
Phone:		
Inspector Informate Administration Inspector:	Doug Hendric	1. A
Lead Inspector: Other Represent	Doug Hendric	21/-)
Lead Inspector: Other Represent	Doug Hendric	200 Area Emissions (DST)
Lead Inspector: Other Represent Emission unit AOP Requirements	Doug Hendric	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001
Lead Inspector: Other Represent Emission unit AOP Requirements Description	Doug Hendrick	200 Area Emissions (DST)
Lead Inspector: Other Represent Emission unit AOP Requirements Description	Doug Hendrick	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).
Lead Inspector: Other Represent Emission unit AOP Requirements Description	Doug Hendrick	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).
Lead Inspector:	Doug Hendrick	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).  AN, AP, AW Ventilation System includes de-entrainer, preheater, prefilter, two stage HEPA, fan, stack. AY, AZ Ventilation System includes condenser, HEME, HEPA/HEGA/HEPA, fan, stack. SY Ventilation System includes de-entrainer
Lead Inspector: Other Represent Emission unit AOP Requirements Description	Doug Hendrick  atives:	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).  AN, AP, AW Ventilation System includes de-entrainer, preheater, prefilter, two stage HEPA, fan, stack. AY, AZ Ventilation System includes condenser, HEME, HEPA/HEGA/HEPA, fan, stack. SY Ventilation System includes de-entrainer, prefilter, two stage HEPA, fan, stack.  720 hr/yr/boiler (3 boilers); Periodic PM and combustion adjustments (min
ead Inspector: Other Represent Emission unit AOP Requirements Description	Doug Hendrick  atives:	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).  AN, AP, AW Ventilation System includes de-entrainer, preheater, prefilter, two stage HEPA, fan, stack. AY, AZ Ventilation System includes condenser, HEME, HEPA/HEGA/HEPA, fan, stack. SY Ventilation System includes de-entrainer, prefilter, two stage HEPA, fan, stack.
ead Inspector: Other Represent Emission unit AOP Requirements Description Constraint/Pollutant	Doug Hendrick  atives:  Requirements Equipment/Support  Observations  Limit Value  Limit Basis Testing	200 Area Emissions (DST)  See AOP Table 1.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).  AN, AP, AW Ventilation System includes de-entrainer, preheater, prefilter, two stage HEPA, fan, stack. AY, AZ Ventilation System includes condenser, HEME, HEPA/HEGA/HEPA, fan, stack. SY Ventilation System includes de-entrainer, prefilter, two stage HEPA, fan, stack.  720 hr/yr/boiler (3 boilers); Periodic PM and combustion adjustments (min. annual) = Good Combustion Practices
ead Inspector: Other Represent Emission unit AOP Requirements Description	Requirements Equipment/Support  Observations  Limit Value  Limit Basis	200 Area Emissions (DST)  See AOP Table I.6: NOC approval conditions in DE00NWP-001  NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).  AN, AP, AW Ventilation System includes de-entrainer, preheater, prefilter, two stage HEPA, fan, stack. AY, AZ Ventilation System includes condenser, HEME, HEPA/HEGA/HEPA, fan, stack. SY Ventilation System includes de-entrainer, prefilter, two stage HEPA, fan, stack.  720 hr/yr/boiler (3 boilers); Periodic PM and combustion adjustments (min. annual) = Good Combustion Practices  DE00NWP-001, Cond. 1B.

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Emission unit		200 Area Emissions (DST)	
AOP Requirements		See AOP Table 1.6: NOC approval conditions in DE00NWP-001	
Description		NOC for installation and operation of a waste retrieval system in double-shell tanks (Project W-211).	
Constraint/Pollutant	Requirements	<del></del>	
Limit Value		No VE beyond property line	
	Limit Basis	DE00NWP-001, Cond. 8A.	
	Testing	Quarterly (Method 9 Not specified.)	
Opacity	Recordkeeping	VE records,	
	Observations	no ogenefication	
	Limit Value		
325	Limit Basis		
Nitrogen Oxides	Testing		
$(NO_x)$	Recordkeeping		
	Observations		
	Limit Value	No. 2 Fuel Oil <0.05 wt% S	
	Limit Basis	DE00NWP-001, Cond. 1B.	
Sulfur Dioxide	Testing		
- · · · · · · · · · · · · · · · · · · ·	Recordkeeping	fuel certification	
(SO <sub>2</sub> )	Observations	No Soul will land all	
		Tonk (love get) adjust a Ac Found	
	Limit Value		
	Limit Basis		
Particulate Matter	Testing	Annual HEPA filter testing to 99.95% for 3E-7m particles.	
(PM)	Recordkeeping		
(1 111)	Observations	na ozerdniz	
	Limit Value		
Omalana Maria and J	Limit Basis		
Carbon Monoxide	Testing		
(CO)	Recordkeeping		
	Observations		
	Limit Value	500 ppm	
	Limit Basis	DE00NWP-001, Cond. 3C.	
	Testing	OVA or similar for fugitive organic emissions during the course of monitoring	
Volatile Organic	-	worker exposure. Minimum once per year during mixer pump operation if	
Compounds (VOC)		operated.	
(,0~)	Recordkeeping	VOC measurements	
	Observations	VOC measurements  Nove in state a	
	Limit Value	<asils< td=""></asils<>	
	Limit Basis	DE00NWP-001, Cond. 1A.	
m :	Testing		
Toxic Air	Recordkeeping		
Pollutants (TAPs)	Observations	no ogenialiones	
		The sylventropics	

Facility Identification:  Ecology Nuclear Waste Program	200 Area Emissions (DST)	Inspection Date:	5/11/2010

### COMPLIANCE ACTIONS REQUIRED

Instructions: The actions identified below are necessary in order to be in compliance with Washington Dangerous Waste Regulations (Chapter 173-303 WAC), or other environmental laws or regulations. Please indicate the date an action is completed and initial each item. If an action is not completed, please note in the "Date Completed" column and explain on back of this page.

Return Completed Form copy of this form to the deadlines to achieve co	amn and explain on back of this page.  In or Request for Extension Upon completion of Washington Department of Ecology at the address impliance may be requested. Please make a requested proposed date(s) for completion, and send it to Ecology will provide a written approval or de	s listed below. And t in writing, include the Ecology Lead	extension of ling the rease Contact by	of the
No. A	ction(s) Needed to Achieve Compliance	By When?	Date Completed	Initial
	AHA			
Questions, Concerns, C	Comments			
Ecology Lead Contact:	Doug Hendrickson, P.E. Washington State Department of Ecology Nuclear Waste Program 3100 Port Of Benton Boulevard Richland, WA 99354	Signature	Janes de mario	
Received By:	Dogd Title: Thoga Chr Complem	aDate: 5/10	10	
This checklist serves as a visits.	a notice of deficiency for technical assistance visits or	a notice of non-com	npliance for o	ther site
If you have any quest	ions about information in this Checklist, pleas	e call the Ecolog	gy Lead Cor	ntact.

Facility Identification:	_200 Area Emissions (DST)	Inspection Date:_	5/11/2010
Ecology Nuclear Waste Program	Page 3 of 3		

# Attachment 7 10-ESQ-305

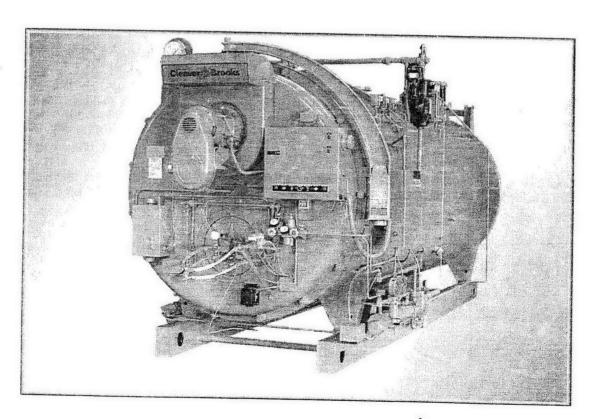
Cleaver-Brooks Model CB, CB-LE Packaged Boiler Operation, Service, and Parts Manual

\$25.00 U.S.

# CLEAVER-BROOKS MODEL CB, CB-LE PACKAGED BOILER

Operation, Service, and Parts Manual

250 through 350hp Fuel: Light Oil, Heavy Oil, Gas or Combination



Manual Part No. 750-91

5/97



DIVISION OF AQUA-CHEM, INC.

### SAFETY PRECAUTIONS AND ABBREVIATIONS

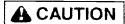
#### **Safety Precautions**

It is essential to read and understand the following safety precautions before attempting to operate the equipment. Failure to follow these precautions may result in damage to equipment, serious personal injury, or death. A complete understanding of this manual is required before attempting to start-up, operate or maintain the equipment. The equipment should be operated only by personnel who have a working knowledge and understanding of the equipment.

The following symbols are used throughout this manual:



This symbol indicates a potentially hazardous situation which, if not avoided, could result in serious personal injury, or death.



This symbol indicates a potentially hazardous situation which, if not avoided, could result in damage to the equipment.

Note: This symbol indicates information that is vital to the operation of this equipment.

#### **Abbreviations**

Following is an explanation of the abbreviations, acronyms, and symbols used in this manual.

AC	Alternating Current
AR	Automatic Reset
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHP	Boiler Horsepower
BTU	British Thermal Unit
°C	Degrees Celsius
CFH	Cubic Feet per Hour
Cu Ft	Cubic Feet
DC	Direct Current
°F	Degrees Fahrenheit
FM	Factory Mutual
FS	Flame Safeguard
ft	Feet
GPM	Gallons per Minute
Hd	Head
нт	Height
НТВ	High Turndown Burner
HZ	Hertz
In H <sub>2</sub> O	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LWCO	Low-Water Cut-Off
М	Million
MFD	Micro-Farad
MR	Manual Reset
NEC	National Electric Code
No.	Number
pН	Measure of the degree of acid or base of a solution
P/N	Part Number
PPM	Parts Per Million
PR	Program Relay
psi	Pounds Per Square Inch
SAE	Society of Automotive Engineers
scfh	Standard Cubic Feet per Hour
T	Temperature
TC	Temperature Control
TI	Temperature Gauge

# MODEL CB, CB-LE PACKAGED BOILER

### **Operation, Service, and Parts Manual**

250 through 350 hp Fuel: Light Oil, Heavy Oil Gas or Combination



DIVISION OF AQUA-CHEM, INC.

Please direct purchase orders for replacement manuals to your local Cleaver-Brooks authorized representative

© Cleaver-Brooks 1994, 1995, 1996

NOTE: If you have a CB-HAWK<sup>TM</sup> Boiler Management Control System, refer to CB-HAWK Installation, Operating and Service Manual No. 750-133 during initial start up, and when referencing Chapters 5, 6, and 7 in this manual.

Manual Part No. 750-91

Revised 5/97

Printed in U.S.A.



DO NOT OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS YOU FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

DO NOT ALLOW OTHERS TO OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS THEY FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

FAILURE TO FOLLOW ALL APPLICABLE WARNINGS AND INSTRUCTIONS MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH.

#### TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warnings may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic burner operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is of extreme importance. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.

The services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices are essential.

The operation of this equipment by the owner and his or her operating personnel must comply with all requirements or regulations of his insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

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### **Chapter 9**

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### **CHAPTER 1**

### **Basics of Firetube Operation**

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#### A. GENERAL

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging from 15 to 800 horsepower. A firetube boiler is a cylindrical vessel, with horizontal tubes passing through and connected to the front and rear tube sheets. The vessel contains the water and absorbs the energy generated from the flame. The front door and rear door provide the seal to contain the hot combustion gasses. Baffles designed into the doors serve to redirect the combustion gasses through the various firetube passages. The flame originates in the furnace. As the combustion gasses travel down the furnace and through the various firetube channels, heat from the flame and combustion gasses is transferred to the water. Transferred energy develops into the required

steam or hot water. The primary purpose of the boiler is to supply energy to the facility's operations - for heat, manufacturing process, laundry, kitchen, etc. The nature of the facility's operation will dictate whether a steam or hot water boiler should be used.

Note: If your boiler is equipped with a CB-HAWK™ boiler management control system, refer to CB-HAWK Installation, Operating and Servicing Manual No. 750-133 for information regarding controls discussed in Chapter 1.

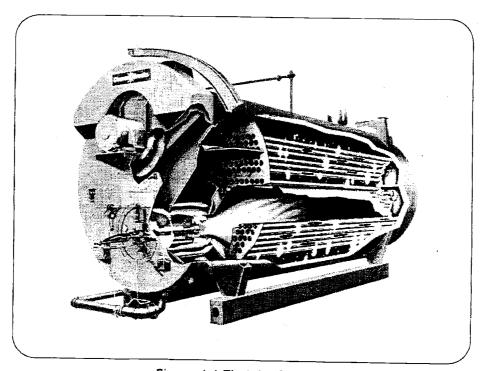


Figure: 1-1 Firetube Cut Away

The general information in this manual applies directly to Cleaver-Brooks Model CB Boilers in sizes ranging from 250 through 350 boiler horsepower for the following fuels:

Series 100 Light Oil (No. 2) Series 200 Light Oil (No. 2) Or Gas Series 400 Heavy Oil (No. 6) Or Gas Series 600 Heavy Oil (No. 6) Only Series 700 Gas Only

Note: Although the Series 400 or 600 burner is designed and designated to burn No. 6 oil, the burner will handle grades 4 and 5 equally well, with some possible adjustments. While the manual contains pertinent information on No. 6 fuel oil, all references to No. 6 fuel should be considered applicable to all grades of heavy oil

Rated Capacity	250 through 350 hp
Operating Pressure	Steam 15-250 psig, or higher if specified
	Hot Water 30-250 psig or higher if specified
Fuel	Oil or Gas or Combination
Ignition	Automatic
Firing	Full Modulation Through Operating Ranges
Burner (Oil)	(Low Pressure) Air Atomizing
Burner (Gas)	Non-premix - Orificed Type
Air Damper	Rotary Type (Electrically Modulated)
Steam Trim	ASME Code
Water Trim	ASME Code

The LE Option, available on Cleaver-Brooks Firetube Boilers, reduces Nitrogen Oxide (NOx) emissions, a major precursor to ozone pollution (smog). Carbon Monoxide (CO) emissions also tend to be lower, due to increased turbulence caused by the addition of the flue gases into the combustion air stream, thereby improving combustion.

The LE Option is used on Cleaver-Brooks Model CB Firetube boilers firing either natural gas and/or light oil, and is compatible with both hot water and steam systems.

The IFGR system mixes a portion of the relatively cool flue gas from the exit of the fourth-pass tubes with the incoming combustion air to reduce the furnace flame temperature, thereby reducing NOx emissions. In this approach, the combustion air fan handles both the combustion air and the recirculated flue gases. Accordingly, this method is called

Induced Flue Gas Recirculation (IFGR), because the flue gas is "induced" into the fan inlet.

The LE Option, with its various levels of IFGR systems, can affect the selection of the combustion air fan, motor, burner, and other components. Several different system configurations are available, depending on the requirements for NOx emissions and the fuels used. All systems use similar primary components, but may have different linkage controls, IFGR damper, fan, and motor sizes.

Always order genuine Cleaver-Brooks parts from your local Cleaver-Brooks authorized representative.

The boiler and related equipment installation are to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained, etc. All boilers in the above series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

#### **B. THE BOILER**

The Model CB boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, air pump, refractory, and appropriate boiler trim.

The horsepower rating of the boiler is indicated by the numbers following the fuel series. Thus, CBT00-250 indicates a gas-fired 250 hp boiler.

The firetube construction provides some characteristics that differentiate it from other better types. Because of its vessel size, the firetube contains a large amount of water, allowing it to respond to load changes with minimum amountain in steam pressure.

Firetube boilers are rated in boiler parkage war. BHP which should not be confused with other parkage war measurements.

Hot water is commonly used in reating LTT LDD To with the boiler supplying water to the system at the Problem The operating pressure for hot water nearing system as a sealing to 30 psig to 125 psig.

Steam boilers are designed for low pressure applications. Low pressure boilers are the first design, and are typically used for heating art to the High

pressure boilers are typically used for process loads and can have a design pressure of 75 to 350 psig.

Steam and hot water boilers are defined according to design pressure and operating pressure. Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler. Typically, the safety valves are set at or below design pressure. Operating pressure is the pressure of the boiler at which it normally operates. The operating pressure usually is maintained at a suitable level below the setting of the pressure relieving valve(s) to prevent their frequent opening during normal operation.

The type of service that your boiler is required to provide has an important bearing on the amount of waterside care it will require.

#### **A** CAUTION

Waterside care is of prime importance. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative. Failure to follow these instructions could result in equipment damage

Feedwater equipment should be checked and ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. Constant attention to water requirements will pay dividends in the form of longer life, less down-time, and prevention of costly repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 3.

The operator should be familiar with Chapter 3 before attempting to place the unit into operation.

#### C. CONSTRUCTION

Steam boilers designed for 15 psig and hot water boilers designed for 250°F at 125 psi or less are constructed in accordance with Section IV, Power Boilers, of ASME Code.

Steam boilers designed for operating pressures exceeding 15 psig are constructed in accordance with Section 1, Power Boilers, of the ASME Code. Hot water boilers designed for operating temperatures above 250°F or 125 psi are likewise built to ASME Code.

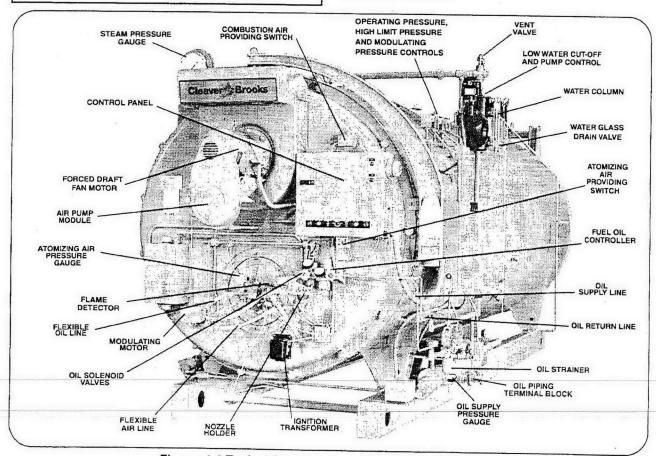
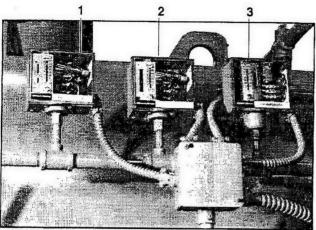


Figure: 1-2 Typical Steam Boiler - Light Oil or Gas Fired



- 1. OPERATING LIMIT CONTROL
- 2. HIGH LIMIT CONTROL
- 3. MODULATING CONTROL

Figure: 1-3 Steam Controls

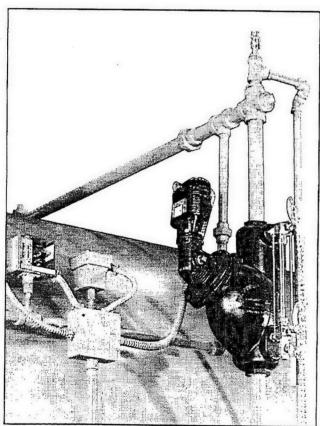


Figure: 1-4 Low Water Cut Off (LWCO)

### D. STEAM CONTROLS (ALL FUELS)

- Operating Limit Pressure Control (Figure 1-3): Breaks a
  circuit to stop burner operation on a rise of boiler
  pressure at a selected setting. It is adjusted to stop or start
  the burner at a preselected pressure setting.
- 2. High Limit Pressure Control (Figure 1-3): Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a presclected pressure above the operating limit control setting. The high limit pressure control is normally equipped with a manual reset.
- Modulating Pressure Control (Figure 1-3): Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."
- 4. Low-Water Cutoff and Pump Control (Figure 1-4): Float-operated control responds to the water level in the boiler. It performs two distinct functions:
  - •Stops firing of the burner if water level lowers below the safe operating point. Energizes the low-water light in the control panel; also causes low-water alarm bell (optional equipment) to ring. Code requirements of some models require a manual reset type of low-water cutoff.
  - •Starts and stops the feedwater pump (if used) to maintain water at the proper operating level (Figure 1-5).

#### A CAUTION

Determine that the main and auxiliary low water cutoffs and pump control are level after installation and throughout the equipment's operating life. Failure to follow these instructions could result in equipment damage.

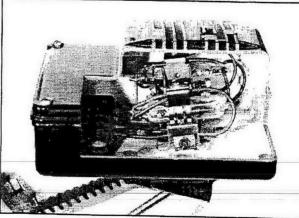


Figure: 1-5 Low Water Cut Off Pump Control (Cutaway)

- Water Column Assembly (Figure 1-6): Houses the lowwater cutoff and pump control and includes the water gauge glass, gauge glass shutoff cocks.
- 6. Water Column Drain Valve (Figure 1-6): Provided so that the water column and its piping can be flushed regularly to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low-water cutoff for the same purpose.
- 7. Water Gauge Glass Drain Valve (Figure 1-7): Provided to flush the gauge glass.
- 8. Vent Valve (Figure 1-7): Allows the boiler to be vented during filling, and facilitates routine boiler inspection as required by ASME Code.
- 9. Stack Temperature Gauge (Figure 1-7): Indicates flue gas outlet temperature.

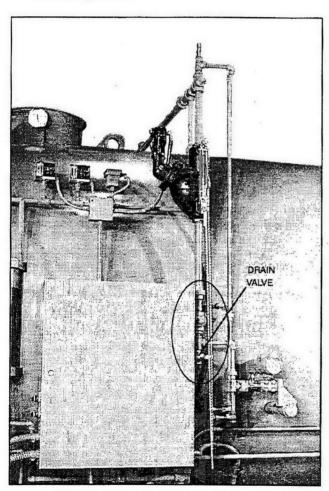


Figure: 1-6 Water Column Assembly

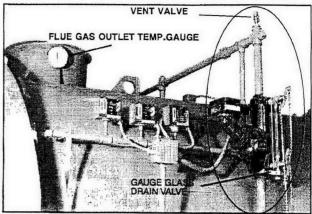


Figure: 1-7 LWCO and Gauge Glass

10. Auxiliary Low-water Cutoff (Figure 1-8): Breaks the circuit to stop burner operation in the event boiler water drops below the master low-water cutoff point. Manual reset type requires manual resetting in order to start the burner after a low-water condition.

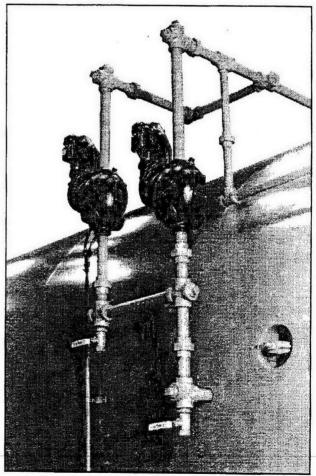


Figure: 1-8 Auxiliary Low Water Cut Off

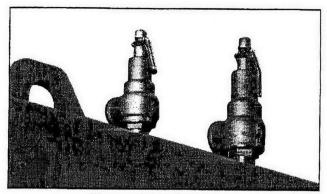


Figure: 1-9 Safety Valves

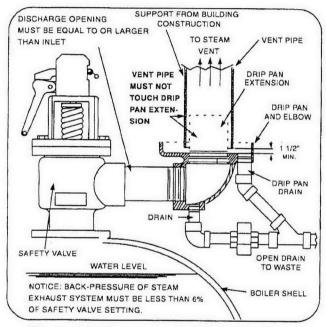


Figure: 1-10 Recommended Piping For Steam Relief Valve (Not furnished by Cleaver-Brooks)

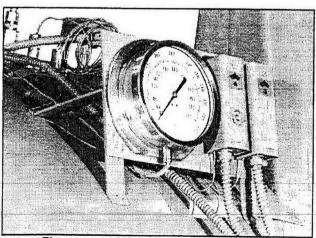


Figure: 1-11 Water Temperature Gauge

11. Safety Valve(s) (Figure 1-9): Prevent buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and coderequired drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, which can distort the seats. Use only flatjawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

#### **A**WARNING

Only properly certified personnel such as the safety valve manufacturer's certified representative can adjust or repair the boiler safety valves. Failure to follow these instructions could result in serious personal injury or death

### E. HOT WATER CONTROLS (ALL FUELS)

- Water Temperature Gauge (Figure 1-11): Indicates the boiler internal water temperature.
- Operating Limit Temperature Control (Figure 1-12):
   Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.
- 3. High Limit Temperature Control (Figure 1-12): Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
- Modulating Temperature Control (Figure 1-12): Senses changing boiler water temperature and transmits the information to the modulating motor to change the

- burner firing rate when the manual-automatic switch is set on "automatic."
- 5. Low-Water Cutoff (Figure 1-13): Breaks the circuit to stop burner operation if the water level in the boiler drops below safe operating point, activating low-water light and optional alarm bell if burner is so equipped.
- Auxiliary Low-Water Cutoff (Not Shown) (Optional):
   Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.
- Safety Valve(s) (Figure 1-9): Relieves the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME Code requirements.

### **AWARNING**

Only properly certified personnel such as the relief valve manufacturer's certified representative can adjust or repair the boiler relief valves. Failure to follow these instructions could result in serious personal injury or death.

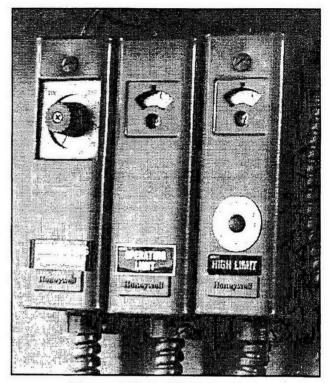


Figure: 1-12 Hot Water Controls

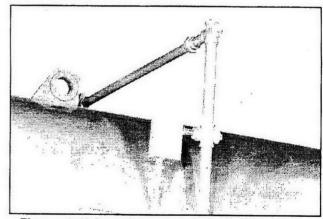


Figure: 1-13 Low Water Cutoff (LWCO Hot Water)

#### F. IFGR COMPONENTS

- Flue Gas Transfer Port, IFGR Damper, and Flange Collar (Figure 1-14). The flue gas transfer port is a tube that allows the flue gases to travel from the exit of the fourthpass tubes to the entrance of the combustion air fan.
  - The IFGR damper controls the volume of flue gas induced into the combustion air stream. The damper is located in the flue gas transfer port and is positioned by the control linkage.
- IFGR Damper Linkage (Figure 1-15). The IFGR damper is positioned by the control linkage. The linkage could consist of a single arm, or it could consist of several arms driven from the jackshaft to provide modulating control (see Figure 1-15).
- Over-Travel Mechanism (Figures 1-14 and 1-15). The over-travel mechanism has two functions. It allows the linkage to pass through the front door, and it allows jackshaft rotation to exceed (over travel) IFGR linkage

- movement. A set of springs allows the linkage to stay in a fixed position while the jackshaft rotates.
- 4. Fuel Change-Over Linkage (Figure 1-15). When a boiler is equipped to fire either gas or oil (dual-fuel boilers), and the required NOx levels are below 60 ppm on natural gas, a dual-linkage arrangement is used to provide the different recirculation rates required for each fuel. Two jackshaft drive arms are provided, one for oil and one for gas. The linkage is manually connected to the appropriate arm, based on the fuel being used.
  - On dual-fuel boilers with two jackshaft drive arms, as defined above, a proximity switch is used to prove that the correct linkage connection is made. (Refer to the wiring diagram provided with the boiler.)
- 5. Fan/Motor Cassette (Figure 1-16). The fan and motor assemblies are designed as a cassette so that they can be removed from the front of the boiler, without opening the front door. The front door davit arm can be used to remove the assembly (Figure 1-16).

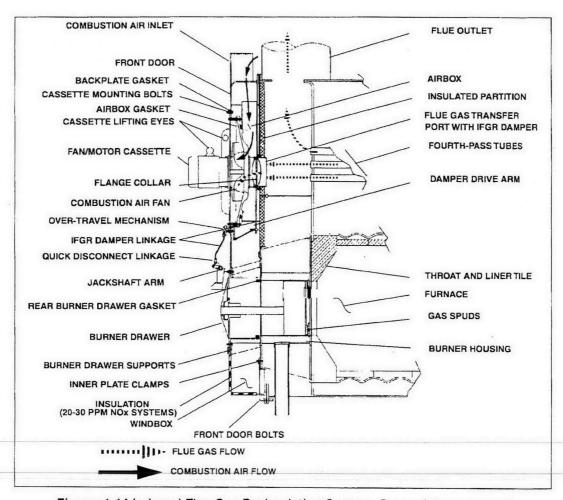


Figure: 1-14 Induced Flue Gas Recirculation System, General Arrangement

- Burner Drawer (Figure 1-14). The gas spudding pattern for the IFGR system may be different than that of a non-IFGR, High-Turndown CB Burner of the same horsepower (HP) model designation.
- Combustion Air Inlet (Figure 1-14). The combustion air inlets are located at the top of the front door. Air enters from the rear of the air inlet shrouds, which reduces the
- sound level and captures heat from the botter and stack flue outlet.
- 8. Front Door Insulation (Figure 1-14). If NO<sub>x</sub> emissions are below 60 PPM, the front door is insulated inside to control temperature build up. The insulation is held in place with wire mesh.

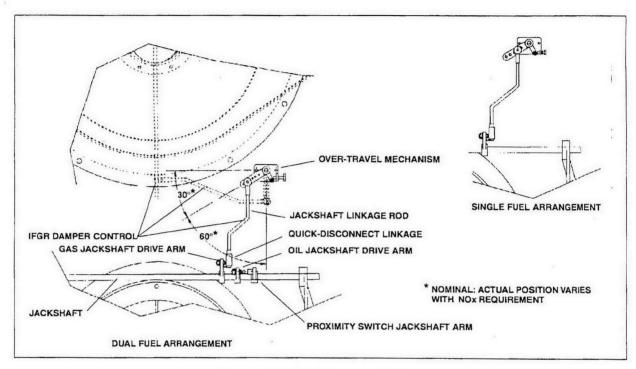


Figure: 1-15 IFGR Damper Linkage

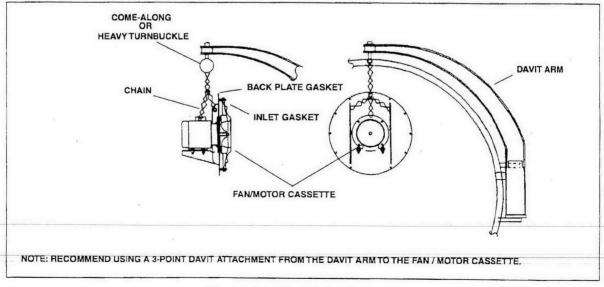


Figure: 1-16 Fan/Motor Cassette

### **CHAPTER 2**

### **Burner Operation and Control**

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#### A. THE BURNER

The oil burner is of the low pressure, air atomizing (nozzle) type. The gas burner is of the non-premix orifice type. The burners are ignited by spark ignited gas pilot. The pilot is of the interrupted type and is extinguished after main flame is established.

Note: A Series 100 boiler is usually equipped with a light oil pilot, although a gas pilot is also available.

Burners equipped to burn oil and gas (combination burners) include equipment for each distinct fuel. Since the burner uses only one type of fuel at a time, a gas/oil selector switch is incorporated.

Regardless of which fuel is used, the burner operates with full modulation (within its rated operating range). The burner returns to minimum firing position for ignition. Highpressure boilers (above 15 psi) can be wired for both low-pressure and high-pressure modulation, which enables the boiler to operate at lower pressure during off-load hours, but at a somewhat reduced steam output, dependent upon lower steam pressure and steam nozzle sizing.

The flame safeguard and program relay include a flame detector to supervise both oil and gas flames, and to shut the burner down in the event of loss of flame. The programming portion of the control provides a pre-purging period, proving of the pilot and main flame, and a period of continued blower operation to postpurge the boiler of all unburned fuel vapor. Other safety controls shut down the burner under low-water conditions, excess steam pressure, or water temperature.

Safety interlock controls include combustion and atomizing air proving switches and, depending upon the fuel and insurance carrier requirements, controls that prove the presence of adequate fuel pressure, plus temperature proving controls when heated fuel oil is used.

The sequence of burner operation from startup through shutdown is governed by the program relay in conjunction

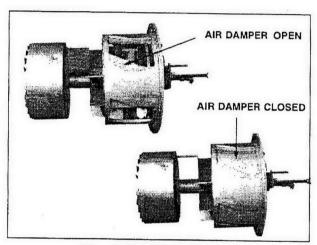


Figure: 2-1 Burner Drawer

with the operating, limit and interlock devices. The devices are wired into the circuitry to provide safe operation and protect against incorrect operating techniques.

All CB boilers have the burner assembly attached to the front head. The entire head may be swung open for inspection and maintenance.

Combustion air is provided by a centrifugal blower located in the front head (Figure 2-5, 2-6). Combustion air flow diagrams for both the CB-LE and the standard CB boiler are shown in figure 2-2 and figure 2-3. Combustion air delivery to the burner is under the control of the modulating motor (Figure 2-4). The motor also regulates the flow of fuel through a linkage system connected to the gas butterfly valve and/or oil through a cam-operated metering valve. Fuel input and air are thus properly proportioned for most efficient combustion.

Filtered primary air for atomizing fuel oil is furnished independently of combustion air by an air pump. The standard 78" firetube boiler is equipped with the belt driven air pump (Figure 2-5). The 78" CB-LE uses the frame mounted air pump (Figure 2-6).

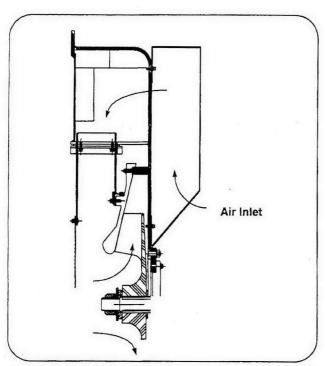


Figure: 2-2 Air Intake Through Front Head (CB-LE)

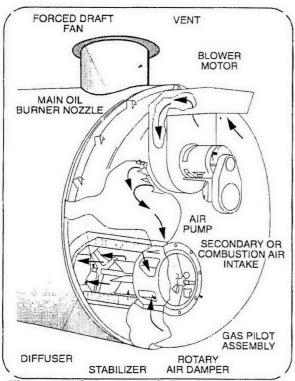


Figure: 2-3 Secondary Air Flow (Standard CB)

The burner control circuit operates on 115 volt, single phase 60 Hz (or 50 Hz when equipped) alternating current. The forced draft fan motor is generally operated on 3-phase service at the available main power supply voltage.

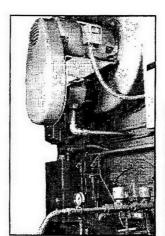


Figure: 2-5 Belt Driven Air Pump



Figure: 2-4 Modulating Motor

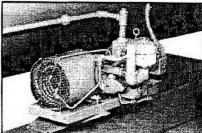


Figure: 2-6 Frame Mounted
Air Pump

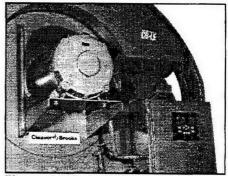


Figure: 2-7 Forced Draft Fan Motor CB-LE

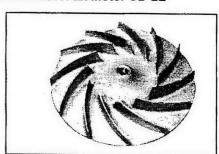
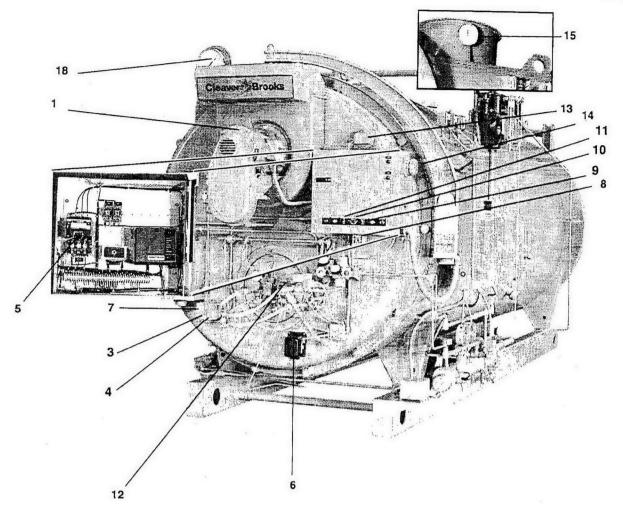


Figure: 2-8 Forced Draft Fan

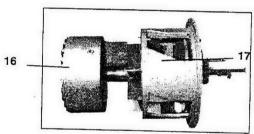
Indicator lights signaling load demand, fuel valve, low water, and flame failure conditions are standard equipment.

In addition to the standard basic controls supplied, other devices may be required to meet specific requirements of an insurance carrier or local code. Refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation to determine the specific controls in the burner and limit control circuits. The function of individual components is outlined in Chapter 2 and the electrical sequence is covered in Chapter 3.



Note: This figure shows front door arrangement for a standard CB. See Figure 2-15 for arrangement with LE.

- 1. FORCED DRAFT FAN MOTOR (FIGURE 2-7)
- 2. FORCED DRAFT FAN (FIGURE 2-8)
- 3. MODULATING MOTOR (FIGURE 2-4)
- 4. MODULATING MOTOR TRANSFORMER
- 5. FORCED DRAFT FAN MOTOR STARTER
- 6. IGNITION TRANSFORMER
- 7. LOW FIRE SWITCH (NOT SHOWN)
- 8. ATOMIZING AIR PROVING SWITCH
- 9. MANUAL-AUTOMATIC SWITCH
- 10. MANUAL FLAME CONTROL
- 11. BURNER SWITCH
- 12. FLAME DETECTOR



- 13. COMBUSTION AIR PROVING SWITCH
- 14. ALARM
- 15. STACK THERMOMETER
- 16. DIFFUSER
- 17. ROTARY AIR DAMPER
- 18. PRESSURE GAUGE

Figure: 2-9 Controls Common to All Boilers

### B. CONTROL AND COMPONENT FUNCTION

The term "control" covers the more important valves and components, including, but not limited to electrical controls or those monitored by the program relay. The operator must become familiar with the individual functioning of all controls before understanding boiler operation and procedures outlined in this manual.

Before proceeding, identify and locate each item using the callout in the illustration.

The actual controls furnished with any given boiler will depend upon the type of fuel for which it is equipped, and whether it is a hot water or steam boiler. Refer to the applicable group or groups within Chapter 2 that apply to the particular boiler.

Boilers with optional features may have control components not listed here.

### C. COMPONENTS COMMON TO ALL BOILERS

- Forced Draft Fan Motor (Figure 2-7): Drives the forced draft fan directly to provide combustion air. Also referred to as a blower motor.
- Forced Draft Fan (Figure 2-8): Provides all air, under pressure, for combustion of pilot fuel and main fuel, and for purging.
- 3. Modulating Motor (Figure 2-4 & 2-9): Operates the rotary air damper and fuel metering valves through a cam and linkage system to provide proper air/fuel ratios under all boiler load conditions.
- Modulating Motor Transformer (Figure 2-9) (located in the mod motor): Reduces control circuit voltage (115 Vac) to required voltage (24Vac) for operation of the modulating motor.
- Forced Draft Fan Motor Starter (Figure 2-9 & 2-10): Energizes forced draft fan (blower) motor.
- 6. Ignition Transformer (Figure 2-9): Provides high voltage spark for ignition of gas pilot or light oil pilot.
- 7. Low Fire Switch (Not Shown, located in the mod motor): An internal auxiliary switch, cam actuated by the motor shaft, which must be closed to indicate that the air damper and fuel metering valve are in the low fire position before an ignition cycle can occur.
- Atomizing Air Proving Switch (Figure 2-10): A
  pressure-sensitive switch actuated by air pressure from
  the Air Pump. Its contacts close to prove presence of
  atomizing air. The fuel valves cannot be energized unless
  this switch is satisfied.

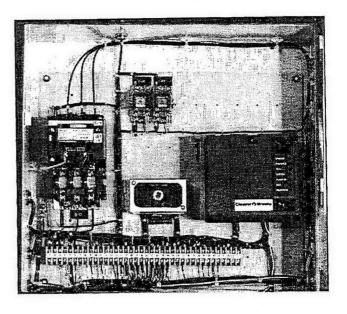


Figure: 2-10 Control Box

- 9. Manual-Automatic Switch (Figure 2-9): When set at "automatic," subsequent operation is at the command of the modulating control, which governs the position of the modulating motor in accordance with load demand. When set at "manual," the modulating motor, through the manual flame control, can be positioned at a desired burner firing rate. The primary purpose of the manual position is for testing and setting the air/fuel ratio through the entire firing range.
- 10. Manual Flame Control (Figure 2-9): A manually operated potentiometer that permits the positioning of the modulating motor to a desired burner firing rate when the manual-automatic switch is set on "manual". It is used primarily for initial or subsequent setting of fuel input throughout the firing range. It has no control over the firing rate when the manual-automatic switch is set on "automatic."
- 11. Burner Switch (Figure 2-9 & 2-10): A manually operated start-stop switch for directly starting and stopping operation of burner.
- 12. Flame Detector (Figure 2-9): Monitors gas or oil pilot and energizes the programmer flame relay in response to a flame signal. It continues to monitor main flame (oil or gas) after expiration of pilot providing period. A standard equipped boiler has a lead sulfide (infrared sensitive) detector.
- 13. Combustion Air Proving Switch (Figure 2-9): A pressure-sensitive switch actuated by air pressure from the forced draft fan. Its contacts close to prove presence

of combustion air. The fuel valves cannot be energized unless this switch is satisfied. The combustion air proving switch is provided on all gas fired or combination gas-oil burners. An oil fired boiler does not normally have a separate switch but utilizes the atomizing air proving switch to the same effect, since the presence of atomizing air from the air pump, which is belt driven from the blower motor, is evidence of blower operation.

- Alarm (Figure 2-9): Sounds to notify the operator of a condition requiring attention. The alarm is available as optional equipment.
- 15. Stack Thermometer (Figure 2-9): Indicates temperature of vented fluc gases.
- 16. Diffuser (Figures 2-9): A circular plate, located at the furnace end of the burner drawer, that imparts a rotary swirling motion to combustion air immediately prior to its entering the flame, thus providing a thorough and efficient mixture with the fuel.
- 17. Rotary Air Damper (Figures 2-9): Provides accurate control of combustion air in proportion to fuel input for various load demands. It consists of two concentric cylinders with openings. The outer is stationary. The inner is rotated, under control of the modulating motor, to vary the effective size of the openings where they overlap.
- 18. Indicator Lights (Figure 2-10): Provide visual information of boiler operation as follows (indicator lights vary with controls provided):
  - •Flame Failure
  - ·Load Demand
  - •Fuel Valve (valve open)
  - ·Low Water
- 19. Program Relay and Flame Safeguard Control (Figure 2-9): Automatically programs each starting, operating and shutdown period in conjunction with operating limit and interlock devices. Includes, in a timed and proper sequence, the operation of the blower motor, ignition system, fuel valve(s), and the damper motor. The sequence includes air purge periods prior to ignition and upon burner shutdown.

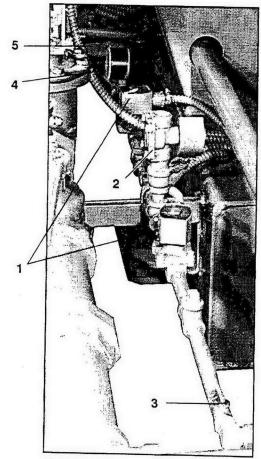
The flame detector portion of the control monitors both oil and gas flames and provides protection in the event of loss of a flame signal.

The control recycles automatically during normal operation, or following a power interruption. It must be manually reset following a safety shutdown caused by a loss of flame. An internal checking circuit, effective on every start, prevents burner operation in the event anything causes the flame relay to hold in during this period.

#### D. CONTROLS FOR GAS FIRING

Depending upon the requirements of the insurance carrier or other governing agencies, the gas flow control system, or gas train, may consist of some, or all, of the following items. Refer to the Dimension Diagram (DD) prepared by Cleaver-Brooks for your specified installation.

- 1. Gas Pilot Valve (Figure 2-10): A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established. The sequence of energizing and de-energizing is controlled by the programming relay. A second gas pilot valve may be required by insurance regulations.
- Gas Pilot Vent Valve (Figure 2-10): When a second gas
  pilot valve is required, a normally open vent valve
  (optional equipment) is installed between them. Its
  purpose is to vent gas to the atmosphere, should any be

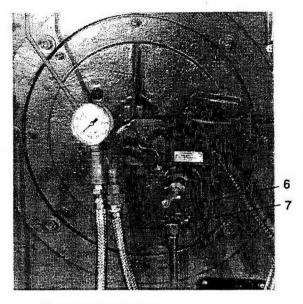


- 1. GAS PILOT VALVES
- 2. GAS PILOT VENT VALVE
- 3. GAS PILOT SHUTOFF COCK
- 4. GAS PRESSURE GAUGE
- 5. GAS PRESSURE REGULATING VALVE

Figure: 2-11 Pilot Gas Train

present in the pilot line when the pilot valves are closed. The valve closes when the pilot valves are energized.

- 3. Gas Pilot Shutoff Cock (Figure 2-10): For manually opening or closing the gas supply to gas pilot valve.
- 4. Gas Pressure Gauge (Figure 2-10): Indicates gas pressure to pilot.
- 5. Gas Pressure Regulating Valve (Figure 2-10): Reduces incoming gas pressure to suit the pilot.
- 6. Gas Pilot Aspirator (Figure 2-12): Provides complete mixing of gas and air to the pilot.
- 7. Gas Pilot Adjusting Cock (Figure2-12): Regulates the size of the gas pilot flame.
- Gas Modulating Cam (Figure 2-13): An assembly, consisting of a quadrant, a series of adjustable allen-head screws and a contour spring, provided for adjustment of gas input at any point in the modulating range.
- 9. Main Gas Cock (Figure 2-14, 15): For manually opening and closing the main fuel gas supply downstream of the main gas line pressure regulator. A second shutoff cock, downstream of the main gas valve(s), is installed to provide a means of shutting off the gas line whenever a test is made for leakage across the main gas valve.
- 10. Butterfly Gas Valve (Figure 2-14, 15): The pivoted disc in the valve is actuated by connecting linkage from the gas modulating cam to regulate the rate of gas flow to the burner.
- 11. Main Gas Valves (Figure 2-14, 15): Electrically actuated shutoff valves that open simultaneously to admit gas to the burner. The downstream valve is equipped with a "proof of closure" switch that is connected into the preignition interlock circuit.
- 12. Main Gas Vent Valve (Figure 2-14, 15): A normally open solenoid valve installed between the two main gas valves to vent gas to the atmosphere should any be present in the main gas line when the gas valves are deenergized. The vent valve closes when the gas valves are energized.
- 13. Low Gas Pressure Switch (Figure 2-14, 15): A pressure-actuated switch that is closed whenever main gas line pressure is above a preselected pressure. Should the pressure drop below the setting, the switch contacts open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. The switch is usually equipped with a device that must be manually reset after being tripped.
- 14. High Gas Pressure Switch (Not Shown): A pressure actuated switch that is closed whenever main gas line pressure is below a preselected pressure. Should the pressure rise above the setting, the switch contacts will



6. GAS PILOT ASPIRATOR
7. GAS PILOT ADJUSTING COCK

Figure: 2-12 Burner Drawer Back Plate

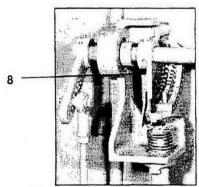


Figure: 2-13 Gas Modulating Cam

open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. The switch is usually equipped with a device that must be manually reset after being tripped.

15. Leakage Connection (Not Shown): The body of the gas valve has a plugged opening that is used whenever it is necessary to conduct a test for possible leakage across the closed valve.

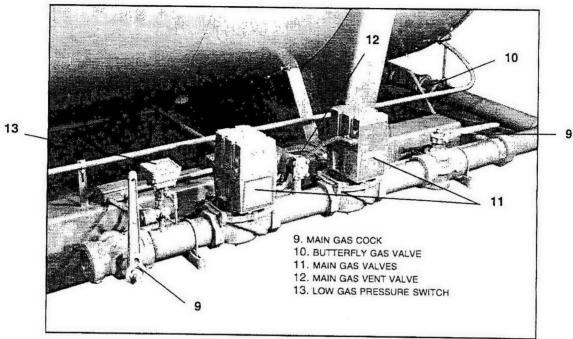


Figure: 2-14 Gas Train

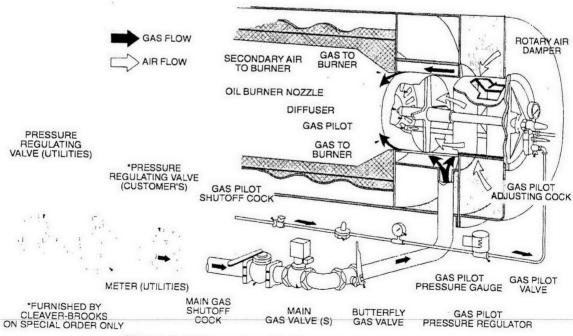


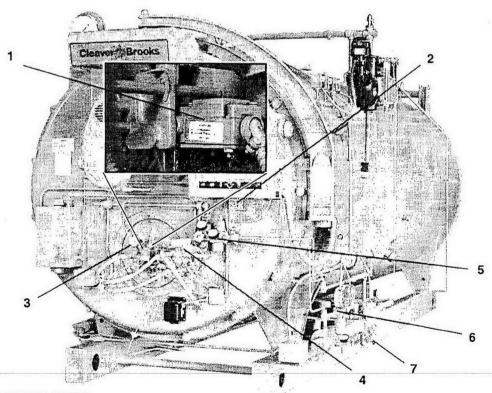
Figure: 2-15 Secondary Air Flow With Gas Train

#### E. CONTROLS COMMON TO OIL-FIRED BOILERS (INCLUDING COMBINATION)

The following items are applicable to all oil fired or gas and oil fired boilers. Additional controls for No. 6 oil are listed in Section I.

- 1. Oil Drawer Switch (Figure 2-16): Opens the limit circuit if oil drawer burner gun is not latched in the forward position required for burning oil.
- Atomizing Air Proving Switch (Figure 2-16): Pressureactuated switch whose contacts are closed when sufficient atomizing air pressure from the air pump is present for oil firing. Oil valve(s) will not open, or will not remain open, unless switch contacts are closed.
- 3. Atomizing Air Pressure Gauge (Figure 2-16): Indicates the atomizing air pressure at the burner gun
- 4. Oil Solenoid Valve (Figure 2-16): Opens when energized through contacts in the programmer and allows fuel oil flow from the oil metering valve to the burner nozzle. A light oil fired burner uses two valves operating simultaneously.

- 5. Fuel Oil Controller (Figures 2-16 & 2-17): An assembly combining into a single unit the gauges, regulators and valves required for regulating the flow of fuel oil. All controllers have the following integral parts. In addition to these, the controller used on a No. 6 oil fired burner has additional components described in Section I.
  - A. Oil Metering Valve: Valve metering stem moves to increase or decrease the orifice area to regulate the supply of fuel oil to the burner nozzle in accordance with boiler load variances. Stem movement is controlled by the modulating motor through linkage and the oil metering cam.
  - B. Oil Modulating Cam: Assembly consisting of a quadrant, a series of adjustable allen-head screws and a contour spring provided for adjustment of oil input at any point in the modulating range.
  - C. Oil Burner Pressure Gauge: Indicates pressure of the fuel oil at the metering valve.
  - D. Oil Pressure Regulator: For adjustment of the pressure of oil at the metering valve.
- Oil Relief Valve (Figure 2-16): Maintains a constant oil supply pressure to the fuel oil controller by bypassing excess fuel oil.



- 1. OIL DRAWER SWITCH
- 2. ATOMIZING AIR PROVING SWITCH
- 3. ATOMIZING AIR PRESSURE GAUGE
- 4. OIL SOLENOID VALVE

- 5. FUEL OIL CONTROLLER
- 6. OIL RELIEF VALVE
- 7. TERMINAL BLOCK

Figure: 2-16 Components Common to Oil Fired Boilers

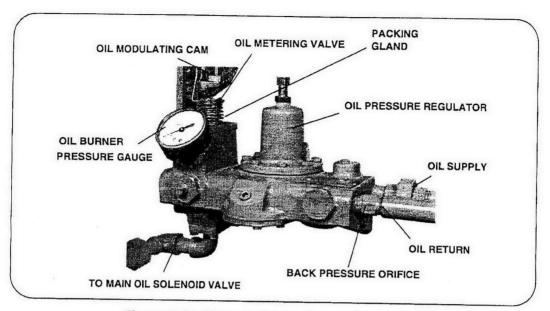


Figure: 2-17 Oil Control Valve Assembly - for Light Oil

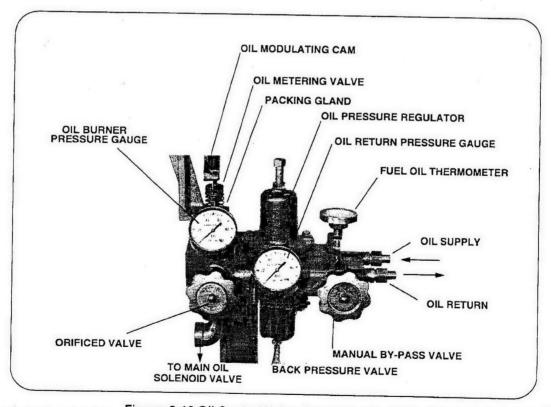
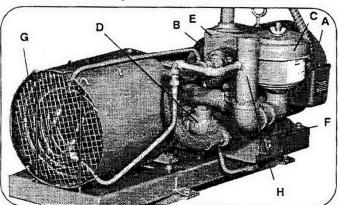


Figure: 2-18 Oil Control Valve Assembly -for Heavy Oil

- 7. Terminal Block
- Fuel Oil Strainer (Not Shown): Prevents foreign matter from entering the burner system.
- Gas Pilot: See Section D of Chapter 2 for description of the various components.
- 10. Light Oil Pilot Valve (Not Shown): When a light oil pilot is furnished, a solenoid valve is provided to control flow of fuel to the pilot nozzle. It is energized through programmer contacts. It is deenergized to shut off pilot fuel flow after main flame is ignited and established.
- Back Pressure Orifice: A restriction located in the oil return line immediately downstream of the fuel oil controller to create back pressure (100 and 200 series only).
- 12. Air Pump Module Assembly (Figures 2-19, 20 & 21): Provides the compressed air required to atomize the fuel oil for proper combustion. The CB-LE air pump module is started automatically by the programmer's sequence. It includes components described A-H. The standard 78" unit uses the belt driven air pump that starts when the blower motor starts.
  - A. Air Pump Motor: Drives the air pump and an air cooling fan. The motor is started and stopped simultaneously with the forced draft fan motor.



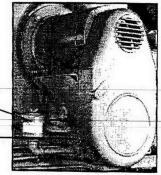
- A. AIR PUMP MOTOR
- B. AIR PUMP
- C. AIR FILTER
- D. CHECK VALVE
- E. AIR-OIL RECEIVER TANK
- F. LUBE OIL LEVEL SIGHT GLASS
- G. LUBE OIL COOLING COIL

Figure: 2-19 Air Pump (Primary Air) CB-LE

Figure: 2-20 Belt Driven Air Pump

AIR FILTER

AIR INTAKE \_ CONTROL VALVE



- B. Air Pump: Provides air for atomization of the fuel oil.
- C. Air Filter: The filter cleans the air supply prior to entering air pump.
- D. Check Valve: Prevents lubricating oil and compressed air from surging back through the pump and air filter when the pump stops.
- E. Air-Oil Receiver Tank: Holds a supply of oil for lubricating the air pump. The receiver tank also separates lube oil from the atomizing air before delivery to nozzle.
- F. Lube Oil Level Sight Glass: Indicates the level of lubricating oil in the air-oil receiver tank.
- G. Lube Oil Cooling Coil: Cools the lubricating oil before it enters the air pump. A fan driven by the air pump motor circulates cooling air over the coil.
- H. Lube Oil Fill Pipe and Strainer: Used when adding oil to the air-oil receiver tank.
- 13. Low Oil Pressure Switch (Optional): Switch contacts open when the fuel oil pressure drops below selected pressure. Switch will interrupt the limit circuit upon loss of sufficient fuel oil pressure for correct combustion.
- Fuel Oil Pump (Not Shown): Transfers fuel oil from the storage tank and delivers it under pressure to the burner system.

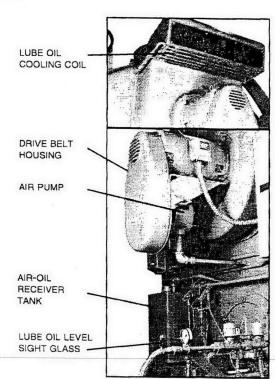


Figure: 2-21 Belt Driven Air Pump Component Locations

### F. ADDITIONAL CONTROLS FOR HEAVY OIL

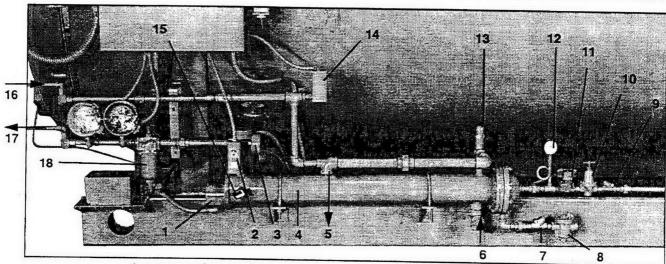
The oil heater (Figure 2-22 Steam) is provided to heat heavy oil to the point where it can be effectively atomized and burned. Most heavy oil heaters utilize an electric heater to reduce the viscosity of the heavy oil until the point where either steam or hot water is available. Heavy oil heaters operating with hot water will have additional controls not represented in Figure 2-22.

Heater Switch (Not Shown): Manually provides power to the oil heater system.

- Oil Heater (Electric): Used for heating sufficient fuel oil for low-fire flow during cold starts before steam or hot water is available for heating. The heater must be turned off during extended boiler lay-up, or at any time the fuel oil transfer pump is stopped.
- 2. Electric Oil Heater Thermostat: Senses fuel oil temperature and energizes or deenergizes the electric oil heater to maintain required temperature of the fuel oil.
- Steam Oil Heater Thermostat: Senses fuel oil temperature and controls the opening and closing of the steam heater valve to maintain the required temperature of the fuel oil.
- 4. Oil Heater Shell (Steam/Hot Water): Heats fuel oil through medium of steam or hot water. Electric heater is

housed in the steam heater, but is housed separately on a hot water heater. Steam oil heaters on 15 psi boilers operate at boiler pressure. Steam oil heaters furnished on high pressure boilers are to be operated at less than 15 psi. Operation is accomplished with a steam pressure regulator valve.

- Oil Return To Tank: Excess oil returned to the heavy oils supply tank.
- 6. Oil Inlet From Supply Tank: Heavy oil inlet from the supply tank.
- Steam Heater Check Valve: Prevents oil contamination of the waterside of pressure vessel should any leakage occur in the oil heater.
- Steam Trap: Drains condensate and prevents loss of steam from the steam oil heater. Condensate must be piped to a safe point of discharge.
- Check Valve (Steam Heater Discharge): Prevents air entry during shutdown periods when cooling action may create vacuum within steam heater.
- 10. Steam Heater Pressure Regulator: Adjust to provide reduced (usually less than 15 psi) steam pressure to the heater to properly maintain the required fuel oil temperature. The regulator and the pressure gauge are not furnished on 15 psi units.
- Steam Heater Solenoid Valve: A normally open solenoid valve opened by the steam oil heater thermostat to allow



- 1. OIL HEATER (ELECTRIC)
- 2. OIL HEATER THERMOSTAT (STEAM)
- 3. OIL HEATER THERMOSTAT (ELECTRIC)
- 4. OIL HEATER SHELL
- 5. OIL RETURN TO TANK
- 6. OIL INLET FROM TANK
- 7. CHECK VALVE 8. STEAM TRAP
- 9. CHECK VALVE

- 10. STEAM HEATER PRESSURE REGULATOR
- 11. STEAM HEATER SOLENOID VALVE
- 12. STEAM PRESSURE GAUGE
- 13. OIL RELIEF VALVE
- 14. LOW OIL TEMPERATURE SWITCH
- 15. OIL SUPPLY PRESSURE GAUGE
- 16. OIL RETURNED FROM FUEL OIL CONTROLLER
- 17. HEATED OIL TO BURNER
- 18. FUEL OIL STRAINER

Figure: 2-22 Oil Heating Assembly (Steam)

#### Chapter 2

- flow of steam to the steam heater to maintain temperature of fuel oil.
- Steam Pressure Gauge: Indicates steam pressure entering the heater.
- 13. Oil Relief Valve: Allows release of excessive pressure to the return side of the oil line piped to the tank.
- 14. Low-Oil-Temperature Switch: Thermostatic switch that prevents burner from starting, or stops burner firing if fuel oil temperature is lower than required for oil burner operation.
- 15. Oil Supply Pressure Gauge: Indicates fuel oil pressure in the oil heater and supply pressure to the fuel oil controller's pressure regulator.

In addition to the components of the fuel oil controller mentioned in Section E, the following are used with a heavy oil fired burner.

- A. High-Oil-Temperature Switch (Optional): Switch contacts open when fuel oil temperature raises above a selected temperature. Switch will interrupt the limit circuit in the event fuel oil temperature rises above the selected point.
- B. Hot Water Oil Heater Thermostat: Used on a hot water boiler to sense fuel oil temperature and control the starting and stopping of the booster water pump.
- C. Booster Water Pump: Started and stopped by the hot water thermostat to regulate the flow of hot water through the hot water oil heater to maintain temperature of fuel oil.
- D. Fuel Oil Thermometer: Indicates temperature of fuel oil being supplied to the fuel oil controller.
- E. Back Pressure Valve: For adjustment of oil pressure on the downstream side of the metering valve. Also regulates rate of return oil flow.
- F. Oil Return Pressure Gauge: Indicates oil pressure on the return side of the fuel oil controller.
- G. Manual By-Pass Valve: Provided as a time saver in establishing oil flow. When open, it permits circulation of oil through the supply and return lines. The valve must be closed prior to initial light off.
- H. Orifice Oil Control Valve: Valve may be opened prior to start-up to aid in establishing fuel oil flow through the controller. The valve must be closed prior to initial light off. Its disc has an orifice to permit a continuous circulation of hot fuel oil through the controller.
- I. Air Purge Valve: Solenoid valve opens simultaneously with closing of oil solenoid valve at burner shutdown, allowing compressed air to purge oil from the burner nozzle and adjacent piping. The oil is burned by the

- diminishing flame, which continues burning for approximately 4 seconds after the oil solenoid valve closes.
- J. Air Purge Orifice Nozzle: Limits purging air to proper quantity for expelling unburned oil at normal delivery rate.
- K. Air Purge Orifice Nozzle Filter: Filters the purging air of any particles that might plug the air purge orifice nozzle.
- L. Air Purge Check Valve: Valve check prevents fuel oil from entering the atomizing air line.
- M.Air Purge Relay: When energized, controls operation of air purge valve.

# G. CONTROLS FOR COMBINATION BURNERS ONLY

(1) Gas-Oil Switch (Figure 2-23): Burners equipped to burn either oil or gas include equipment for each fuel. The selector switch engages the appropriate interlocks and controls for gas or oil operation. Chapter 4 details the required mechanical functions of each fuel system.

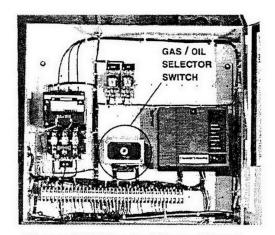


Figure: 2-23 Standard Control Panel

#### H. COMBUSTION AIR

Air for combustion of fuel (often referred to as "secondary" air) is furnished by the forced draft fan (Figure 2-24) mounted in the boiler head. In operation, air pressure is built up in the entire head and is forced through a diffuser plate for a thorough mixture with the fuel for proper combustion. The supply of secondary air to the burner is governed by automatically throttling the output of the fan by regulating the rotary air damper. The damper provides the proper amount of air for correct ratio of air to fuel for efficient combustion at all firing rates.

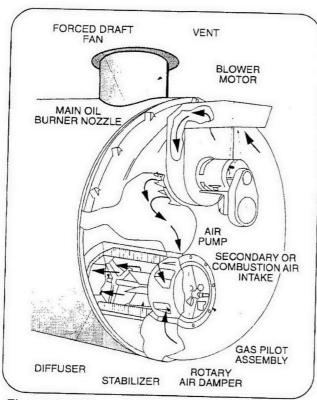


Figure: 2-24 Secondary Air Flow Diagram (CB-LE)

# I. AUTOMATIC IGNITION

Oil or gas burners are ignited by an interrupted-type pilot. The pilot flame is ignited automatically by an electric spark.

The series 100 burner usually is equipped with a pilot fired with light oil fuel. All other burners are equipped with a gas burning pilot. In the case of a combination burner, the gas pilot is used to ignite either the main gas flame or the oil flame. Either pilot serves the same function. Unless exception is taken in the text, the term pilot is used interchangeably.

At the beginning of the ignition cycle, and governed by the program relay, the pilot solenoid valve and ignition transformer are simultaneously energized.

The ignition transformer supplies high voltage current for the igniting spark. A gas pilot has a single electrode and a spark arcs between the tip of the electrode and the wall of the tube surrounding it. A light oil pilot has two electrodes and the arc is between their tips. The pilot solenoid valve and the transformer are deenergized after main flame is ignited and established.

Fuel for the gas pilot is supplied from the utility's main, or from a tank (bottle) supply. Secondary air flows into and mixes with the pilot gas stream to provide an adequate flame. Insurance regulations may require two gas pilot solenoid valves with a normally open vent valve between them. The vent valve closes when the gas pilot valves open, and opens when the gas pilot valves shut to vent gas, should any be present in the pilot line during the deenergized period of the gas pilot valves.

Fuel for a light-oil pilot is provided from the line that supplies oil under pressure for the main flame. A solenoid actuated valve controls flow of oil to the pilot nozzle. The valve is energized simultaneously with the ignition transformer at the beginning of the ignition cycle and is deenergized after main flame is ignited and established.

## J. ATOMIZING AIR

Air for atomizing the fuel oil (often referred to as "primary air") is pumped by the air pump into the air-oil receiver tank and delivered under pressure through a manifold block to the oil burner nozzle.

The atomizing air mixes with the fuel oil just prior to the oil leaving the nozzle.

Atomizing air pressure is indicated by the air pressure gauge on the burner gun.

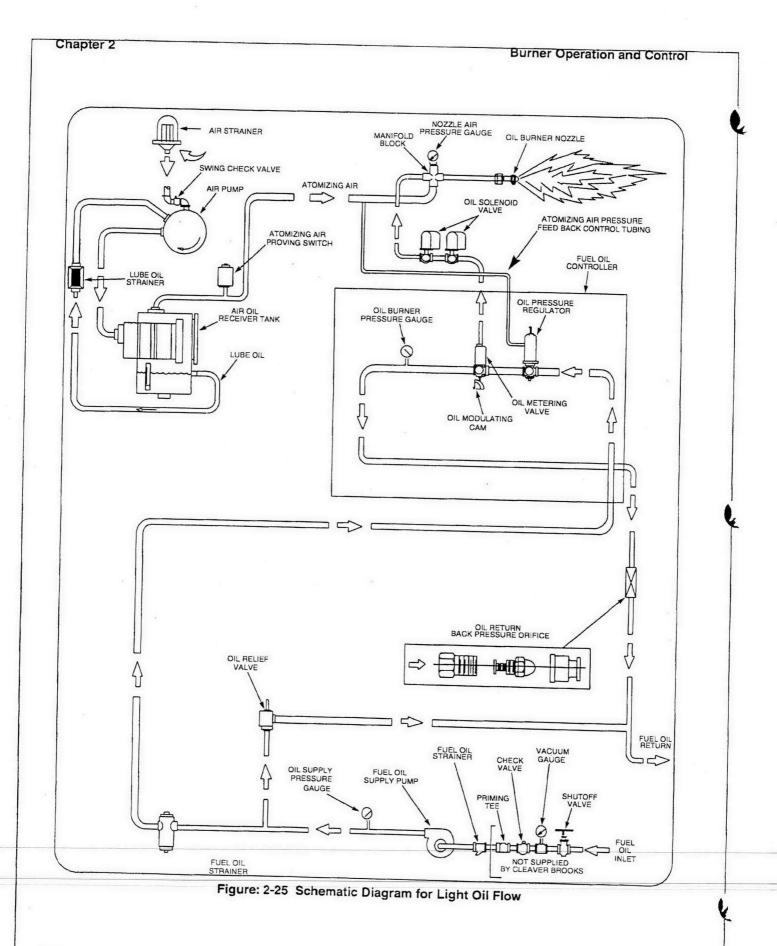
Air pressure from the pump also forces sufficient oil from the tank to the pump bearings to lubricate them and also to provide a seal and lubrication for the pump vanes. As a result, the air delivered to the tank contains some lube oil; however, most of it is recovered through baffles and filters in the tank before the air passes to the burner.

Some of the primary air is also used to assist the oil pressure regulators of the fuel oil controller. Further explanation is given in chapter 5.

# K. OIL FUEL FLOW - LIGHT OIL

The oil fuel flow system schematic is shown in Figure 2-25. Oil flow is indicated by arrows and the pertinent controls are called out. Fuel oil is delivered into the system by a supply pump which delivers part of its discharge to the oil burner. Excess oil is returned to the oil storage tank through the fuel oil relief valve and oil return line. Normally the pump operates only while the burner is in operation, although a positioning switch is often provided so that either continuous or automatic pump operation can be obtained.

The oil flows through a fuel oil strainer to prevent any foreign material from flowing through the control valves and nozzle. The fuel oil controller contains in a single unit, a metering valve, a regulator, and a gauge required to regulate the pressure and flow of oil to the burner. The adjustable regulator controls the pressure. To assist in the regulation, back



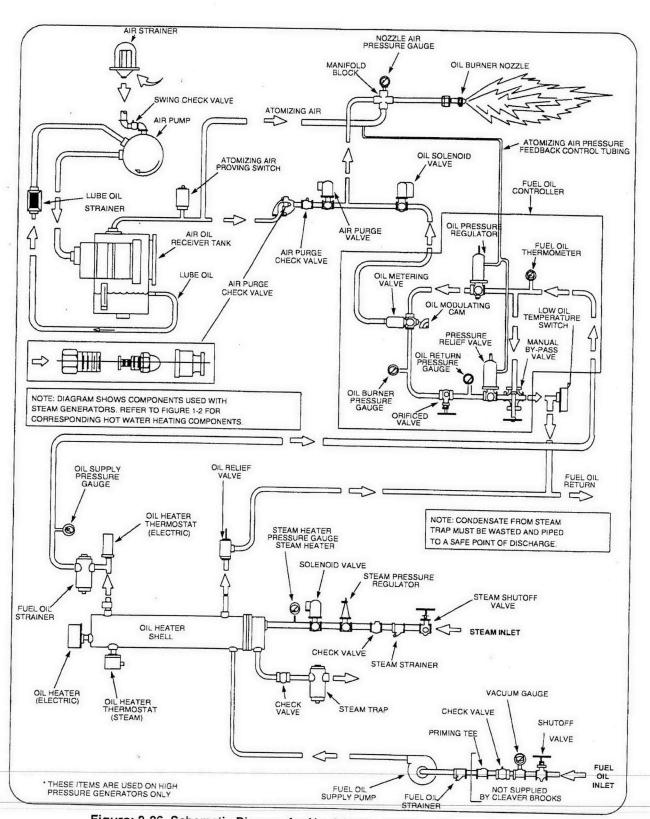


Figure: 2-26 Schematic Diagram for No. 6 Heavy Oil Flow (Steam-Electric Heater)

pressure is created by an orifice nozzle located in the oil return line immediately downstream of the fuel oil controller.

The programming relay energizes or deenergizes the solenoid oil valves to permit or cut off oil flow to the burner. Two valves, operating simultaneously, are used. The valves are closed when deenergized. They cannot be opened (energized) unless the combustion air proving switch and the atomizing air proving switch are closed. The two switches are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan and pressurized air from the air pump.

The oil flow to the burner is controlled by the movement of the metering stem in the oil metering valve, which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by the modulating motor to proportion combustion air and fuel for changes in load demand.

#### L. OIL FUEL FLOW - HEAVY OIL

The oil fuel flow and circulating system is shown in schematic diagram form in Figures 2-26. The pertinent controls are called out and the oil flow is indicated by arrows.

Fuel oil is delivered into the system by the fuel oil supply pump which delivers part of its discharge to the oil heater. The remainder of the fuel oil returns to the oil storage tank through a fuel oil relief valve and oil return line.

The combination electric and steam oil preheater is controlled by thermostats. The electric oil heater thermostat energizes the electric heater, which is provided to supply heated oil on cold starts. The steam heater thermostat controls operation of the steam solenoid valve to permit a flow of steam to the heater when steam is available.

A hot water boiler is equipped to heat the oil with hot water from the boiler, unless other preheating equipment is utilized. The electric heater, which is housed separately, is sized to provide heated oil on a cold start. The hot water thermostat controls the operation of a pump that supplies hot water to the oil heater when hot water is available.

The heated oil flows through a fuel oil strainer to prevent any foreign matter from entering the control valves and nozzle.

The fuel oil controller contains, in a single unit, the necessary valves, regulators and gauges to regulate the pressure and flow of oil to the burner.

The program relay energizes or deenergizes the solenoid oil valve to permit or cut off oil flow to the burner. The oil solenoid is closed when deenergized. It cannot be opened (energized) unless the combustion air proving switch, the atomizing air proving switch, and the low oil-temperature and any pressure switches are closed. They are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan, pressurized air from the air pump and sufficient oil temperature and pressure.

Oil flow to the burner is controlled by the movement of the metering stem of the oil metering valve, which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by the modulating motor to proportion combustion air and fuel for changes in load demand.

Oil is purged from the burner gun upon each burner shutdown. The air purge solenoid valve opens as the fuel valve closes, diverting atomizing air through the oil line. The air assures a clean nozzle and line for subsequent restart.

#### M. GAS FUEL FLOW

Metered gas from the utility flows through the pressure regulator at a reduced pressure suitable to burner requirements, through the main gas shutoff cock, main gas valve(s), and modulating butterfly gas valve to the non-premix orifice-type burner.

The main gas valve is of the normally closed type, and is opened (energized) in proper sequence by the programming relay.

The butterfly gas valve modulates the flow of gas from low through high fire settings. The position of the butterfly valve disc is governed by the gas modulating cam. The butterfly gas valve, and the air control damper are controlled simultaneously by the modulating motor to proportion combustion air and fuel for changes in load demand.

The gas flow rate required for rated burner input depends upon the heating value (Btu/cubic foot) of the gas supplied. The gas pressure regulator adjusts the gas pressure (flow rate) to the entrance of the gas train. The regulator is not always supplied with the burner, but may be provided by others.

The main gas valves cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air. The low gas pressure and high gas pressure switches must be closed to prove sufficient, but not excessive, gas fuel pressure.

#### N. MODULATING FIRING

The modulating motor, through a linkage arrangement (Figure 2-27), controls the air damper and the butterfly gas valve, or the oil metering valve, to maintain a constant air/fuel ratio throughout the firing range.

During burner operation, the motor is controlled by a modulating pressure control on a steam boiler, or by a modulating temperature control on a hot water boiler. A manually operated potentiometer is provided to permit positioning of the motor at the desired burner firing rate. The potentiometer is used primarily for initial or subsequent checking and setting of fuel input. Normal operation should be with the manual-automatic switch in the "automatic" position and under the control of the modulating control.

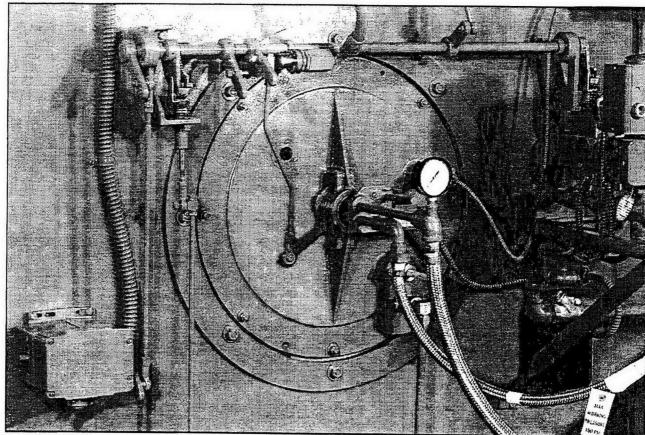


Figure: 2-27 Burner Drawer and Fuel Linkage Assemblies.

The modulating motor (commonly called a damper motor) is control have any control over the damper motor, regardless of reversible. It has an internal limit switch that restricts shaft rotation to 90°. During normal operation the motor will move in either direction or stop at any position within the range.

The motor potentiometer is electrically connected to a matching potentiometer in the modulating control. Changing steam pressure or water temperature alters the electrical resistance of the modulating controller potentiometer. The change in resistance compels an integral balancing relay to start, stop, or reverse the motor rotation. Rotation in either direction continues until the resistance ratio of the two potentiometers is equal.

When the resistance ratio is equal, the motor stops in a position that allows the proper fuel and combustion air flow to meet operating demands.

A feature designed into the circuitry maintains the modulating motor in the low-fire position during ignition and keeps it there until the main flame is established. A low-fire switch, integral to the motor, is actuated by the rotation of the motor. The switch must be closed to establish that the damper and fuel metering valves are in the low-fire position before the programmer commences into the ignition period. During this time, neither the manual flame control nor the modulating

their setting.

An optionally equipped boiler uses a second integral switch to establish that the motor has driven the damper to an open position during the pre-purge period. The second integral switch closes, as high fire position is approached, to complete an internal circuit in the programmer to allow continuation of the programming cycle.

# CHAPTER 3 WATERSIDE CARE AND REQUIREMENTS

A. General
B. Water Requirements
C. Water Treatment
D. Cleaning
E. Boil-out Of A New Unit
F. Washing Out
G. Blowdown Steam Boiler 3-7
H. Periodic Inspection
I. Preparation For Extended Lay-up 3-9

#### A. GENERAL

The operator should be familiar with Chapter 3 before attempting to place the unit into operation.

Although it is of prime importance, the subject of water supply and treatment cannot adequately be covered in this manual. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative.

Feedwater equipment should be checked and ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove the accumulations is described later in Chapter 3.

Boilers, as a part of a hot water system, require proper water circulation. The system must be operated as intended by its designer in order to avoid thermal shock or severe, possibly damaging, stresses from occurring to the pressure vessel.

Note: This manual only covers boilers using water. Glycol solutions have different operating requirements, circulation rates and temperatures, etc.

### **B. WATER REQUIREMENTS**

#### 1. HOT WATER BOILER

#### Air Removal

The hot water outlet includes a dip tube which extends 2 to 3 inches into the boiler. The dip tube reduces the possibility of air, which may be trapped at the top of the shell, from entering into the system. Oxygen or air released in the boiler will collect or be trapped at the top of the boiler shell.

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Air trapped at the top of the boiler will find its way out of the boiler through the tapping.

Minimum Water Temperature - The minimum recommended boiler water temperature is 170°F. When water temperatures lower than 170°F are used, the combustion gases are reduced in temperature to a point where water vapor condenses, causing corrosion in the boiler and possible breeching.

Condensation is more severe on a unit that operates intermittently and which is greatly oversized for the actual load. Condensation can be minimized by maintaining boiler water temperatures above 170°F.

A temperature of 170°F is also recommended in order to provide a sufficient "temperature head" when No. 6 fuel oil is to be heated to the proper atomizing temperature by the boiler water in a safety-type oil preheater. (The electric preheater on the boiler must provide additional heat to the oil if boiler water temperature is not maintained above 200°F.)

Note: If the operating water temperature going to the system must be lower than 170°F, the operating boiler water temperature should be a minimum of 170°F (200 °F if used to preheat No. 6 oil) and mixing valves should be used to avoid damage to the equipment.

Rapid Replacement of Boiler Water - The system layout and controls should be arranged to prevent the possibility of pumping large quantitics of cold water into a hot boiler, which will cause shock or thermal stresses. Water temperature in a boiler of 200°F or 240°F cannot be completely replaced with 80°F water in a few minutes time without causing thermal stress. The same fact applies to periods of normal operation, as well as during initial start-up.

Note: The circulating pumps should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running in order to avoid damage to the equipment.

When individual zone circulating pumps are used, it is recommended that they be kept running-even though the heat users do not require hot water. The relief device or by-pass valve will thus allow continuous circulation through the boiler and can help prevent rapid replacement of boiler water with cold zone water.

Continuous Flow Through the Boiler - The system should be piped and the controls arranged to allow water circulation through the boiler under all operating conditions. The operation of three-way valves and system controls should be checked to be sure that the boiler will not be by-passed. Constant circulation through the boiler eliminates the possibility of stratification within the unit and results in more even water temperatures to the system.

A rule of thumb of 3/4 to 1 gpm per boiler horsepower can be used to determine the minimum continuous flow rate through the boiler under all operating conditions. The operator should determine that a flow of water exists through the boiler before initial firing or refiring after boiler has been drained.

#### Water Circulation

The chart in Figure 3-1 shows the maximum gpm circulation rate of boiler water in relation to full boiler output and system temperature drop.

Multiple Boiler Installations - When multiple boilers are used, care must be taken to ensure adequate or proportional flow through the boilers. Proportional flow can best be accomplished by use of balancing valves and gauges in the supply line from each boiler. If balancing valves or orifice plates are used, a significant pressure drop (e.g., 3-5 psi) must be taken across the balancing device to accomplish the purpose.

If care is not taken to ensure adequate or proportional flow through the boilers, wide variations in firing rates between the boilers can result.

In extreme cases, one boiler may be in the high-fire position while the other boiler or boilers may be at low fire. The net result would be that the common header water temperature to the system would not be up to the desired point.

**Pump Location** - It is recommended that the system circulating pumps take suction from the outlet connection on the boiler, and that they discharge to the system load. In order to put the boiler and the expansion tank on the suction side of the pump. The suction side is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

It is common practice to install a standby system circulating pump. The main circulating pumps are usually located adjacent to the boilers in the boiler room.

**Pump Operation -** Pumps are normally started and stopped by manual switches. It is also desirable to interlock the pump with the burner so that the burner cannot operate unless the circulating pump is running.

#### **Pressure**

The design of the system and usage requirements often dictate the pressure exerted upon the boiler. Some systems are pressurized with air, or with an inert gas such as nitrogen. Caution must be exercised to ensure that the proper relationship of pressure-to-temperature exists within the boiler so that all of the boiler's internal surfaces are fully wetted at all times. For this reason, the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in Figure 3-3.

When initially firing a newly installed boiler, or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to opening the header valves.

It is advisable to have a thermometer installed in the return line to indicate return water temperature. Knowing the supply water temperature, the boiler system differential can be established. With knowledge of the pumping rate, the operator can easily detect any excessive load condition and take appropriate corrective action.

Special caution must be taken to guard against any condition, or combination of conditions, that might lead to the transfer of cold water to a hot boiler or hot water to a cold boiler. It cannot be over-emphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

BOILER	BOILER OUT-	SYSTEM TEMPERATURE DROP - DEGREES °F									
SIZE (BHP)	PUT (1000) BTU/HR	10	20	30	40	50	60	70	80	90	100
			MAXIMUM CIRCULATING RATE - GPM								
15	500	100	50	33	25	20	17	14	12	11	10
20	670	134	67	45	33	27	22	19	17	15	13
30	1,005	200	100	67	50	40	33	29	25	22	20
40	1,340	268	134	89	67	54	45	38	33	30	27
50	1,675	335	168	112	84	67	56	48	42	37	33
60	2,010	402	201	134	101	80	67	58	50	45	40
70	2,345	470	235	157	118	94	78	67	59	52	47
80	2,680	536	268	179	134	107	90	77	67	60	54
100	3,350	670	335	223	168	134	112	96	84	75	67
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

Figure: 3-1 Maximum Circulating Rate

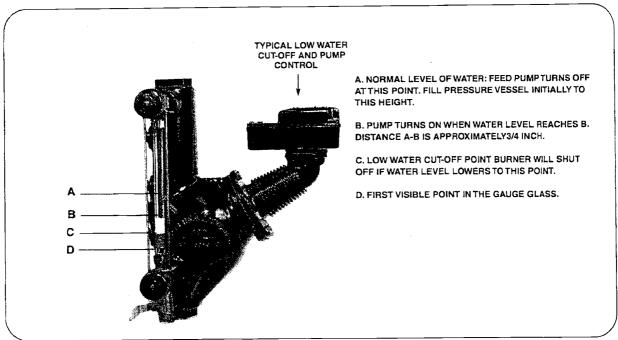


Figure: 3-2 Low Water Cut Off Sight Gauge

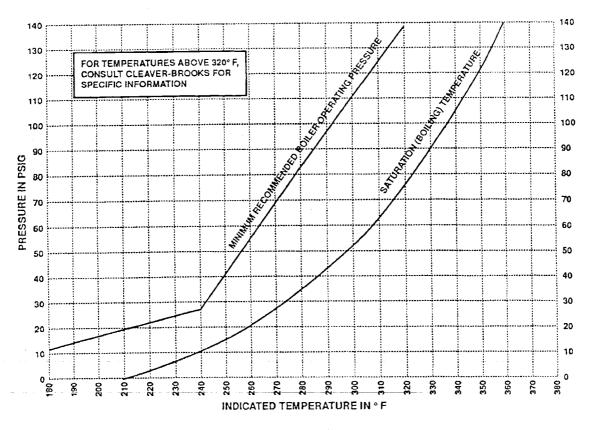


Figure: 3-3 Internal Boiler Pressure

#### 2. STEAM BOILER

#### Feed Pump Operation

BEFORE turning on the pump motor be certain that all valves in the water feed line are open to prevent possible damage to the feed pump mechanism. After opening the valves, momentarily energize the feed pump motor to establish correct pump rotation. With the correct rotation established, close the boiler feed pump entrance switch. The pump should shut down when the water level reaches the proper level shown in Figure 3-2.

Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check the feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

Note: Prior to operating the pump, carefully check the alignment of the flexible coupling, if one is used. A properly aligned coupling will last a long time and provide trouble-free mechanical operation.

#### Water Feeder (optional) Operation

Water feeder operation is usually applicable to boilers operating at 15 psi steam or less. It is only necessary to open the water supply line valve and the water feeder discharge valve.

Note: In the event that water column isolation valves are provided or installed, it must be established that the valves are open and seated or locked in the open position. If the valves are installed, it is illegal to operate the boiler with closed or unsealed open valves.

# **WARNING**

The isolation valves and the water column piping must be locked open during operation. Failure to do so may result in a low water condition. Failure to follow these instructions could result in serious personal injury or death

### C. WATER TREATMENT

Properly treated boiler feed water, coupled with good engineering and operating practices, lead to maximum effectiveness and long trouble-free life of pressure vessels, at the lowest operating cost. Contact your local Cleaver-Brooks authorized representative for information on how to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment in general are:

- (1) Prevent hard scale deposits or soft sludge deposits, which reduce heat transfer and can lead to overheated metal and costly downtime and repairs.
- (2) Eliminate corrosive gases in the supply or boiler water,
- (3) Prevent intercrystalline cracking or caustic embrittlement of boiler metal.
- (4) Prevent carryover and foaming.

Accomplishment of the above objectives generally requires proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, amount of makeup water needed, plant operating practices, etc. Treating methods include filtering, softening, de-mineralizing, deaerating, and preheating. Aftertreatment involves chemical treatment of the boiler water.

Because of the variables involved, no single boiler compound can be considered a "cure-all" nor is it advisable to experiment with homemade treating methods. Sound recommendations and their employment should be augmented by a periodic analysis of the feedwater, boiler water, and condensate.

The internal or waterside surfaces of the pressure vessel should be inspected with enough frequency to determine the presence of any contamination, accumulations of foreign matter, or corrosion, and/or pitting. If any of the conditions are detected, contact your local Cleaver-Brooks authorized representative for advice on corrective action.

A properly sized water meter should be installed in the raw water make-up line in order to accurately determine the amount of raw water admitted to the boiler (steam or hot water) and to aid in maintaining proper waterside conditions.

#### D. CLEANING

## 1. HOT WATER AND STEAM PIPING

Steam and water piping systems connected to the boiler may contain oil, grease, or foreign matter. The impurities must be removed in order to prevent damage to pressure vessel heating surfaces. On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make-up so that an accumulation of unwanted materials or corrosion does not occur. For more information, contact your local Cleaver-Brooks authorized representative.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

#### 2. PRESSURE VESSEL

The waterside of the pressure vessel must be kept clean from grease, sludge, and foreign material. Such deposits, if present, will shorten the life of the pressure vessel, will interfere with efficient operation and functioning of control of safety devices, and quite possibly cause unnecessary and expensive re-work, repairs, and down-time.

The installation and operating conditions that the boiler will be subjected to should be considered and cleaning of the waterside of the pressure vessel should be provided during the course of initial start-up.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned, it is possible that:

- (1) Cleaning has been inadequate.
- (2) Partial or total old system is involved.
- (3) Conditions may prevent adequate cleaning of piping.

The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6-, 9-, or 12-month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed, contact your local Cleaver-Brooks authorized representative for recommendations.

Any sludge, mud or sediment found will need to be flushed out. If excessive mud of sludge is noticed during the blowdown the scheduling or frequency of blowdown may need to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces should be removed promptly by a boil-out with an alkaline detergent solution.

Note: Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code.

#### E. BOIL-OUT OF A NEW UNIT

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed because they lower the heat transfer rate and could cause over-heating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

### **A** WARNING

Use of a suitable face mask, goggles, rubber gloves, and protective garments must be worn when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing. Failure to follow these instructions could result in serious personal injury or death

Your local Cleaver-Brooks authorized representative will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unscheduled, the following information may be of assistance.

There are several chemicals suitable for boil-out. One combination often used is soda ash (sodium carbonate) and caustic soda (sodium hydroxide) at the rate of 3 to 5 pounds each per 1,000 pounds of water, along with a small amount of laundry detergent added as a wetting agent.

The suggested general procedure for cleaning a boiler is as follows:

- (1) Refer to Figure 3-4 to determine water capacity. Have sufficient cleaning material on hand to complete the job.
- (2) When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.
- (3) An over-flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.
- (4) Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate the valves. Use care in removing and reinstalling the valves.

Refer to Chapter 8, Section M for valve installation instructions

G	ENERATOR	WATER -	GALLONS	WATER - WEIGHT		
	SIZES CB & CB-LE	NORMAL	FLOODED	NORMAL	FLOODED	
	250 HP	1280	1665	10670	13880	
	300 HP	1560	2020	13000	16840	
	350 HP	1855	2410	15465	20090	

Figure: 3-4 Water Capacity and Weights



- (5) All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.
- (6) Fill the pressure vessel with clean water until the top of the tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in the initial fill should be at ambient temperature.
- (7) The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. Do not produce steam pressure.
- (8) Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
- (9) Continue the boil and overflow process until the water clears. Shut the burner down.
- (10) Let the boiler cool to 120°F or less.

# **WARNING**

Be sure to drain the hot water to a safe point of discharge to avoid scalding. Failure to follow these instructions could result in serious personal injury or death

- (11) Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
- (12) Inspect the surfaces. If they are not clean, repeat the boil out
- (13) After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180°F to drive off any dissolved gases, which might otherwise corrode the metal.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean. However, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, be sure make-up water is treated to prevent an accumulation of unwanted materials or corrosion.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

# F. WASHING OUT

## 1. HOT WATER BOILER

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and water treated), and with no

make-up water added, will require no further cleaning or treatment. However, since the system (new or old) can allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient. However, if there is any doubt, the pressure vessel waterside should be inspected no later than three months after initially placing the boiler into operation, and periodically thereafter as indicated by conditions observed during inspections.

#### 2. STEAM BOILER

No later than three months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature. Handhole covers should be removed and waterside surfaces should be inspected for corrosion, pitting, or formation of deposits.

### Flushing of Pressure Vessel Interior

Upon completion of the inspection, the pressure vessel interior should be flushed out, as required, with a high pressure hose. If deposits are not fully removed by flushing, a consultation may be required with your local Cleaver-Brooks authorized representative. In extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

The inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washouts. Contact your local Cleaverbrooks authorized representative for more information.

# G. BLOWDOWN STEAM BOILER

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that the lowering of the concentration of solids in the boiler water occurs.

Solids are brought in by the feedwater even though the water is treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of the processes can remove all substances. Regardless of their high efficiency, some solids will be present in the boiler feedwater.

Solids become less soluble in the high temperature of the boiler water and tend to accumulate on heating surfaces. Therefore blowdown and internal chemical treatment are required to prevent the solids from forming harmful scale and sludge.

#### Chapter 3

Scale has a low heat transfer value and acts as an insulation barrier. Scale retards heat transfer, which not only results in lower operating efficiency, and consequently higher fuel consumption, but more importantly, can cause overheating of boiler metal. Over heating of boiler metal can result in tube failures or other pressure vessel metal damage and lead to boiler down-time and costly repairs.

Scale is caused primarily by calcium and magnesium salts, silica and oil. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate, along with organic materials, to maintain the precipitates or "sludge" in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale. But as the boiler water boils off as relatively pure steam, the remaining water is thickened with the solids. If the concentration is permitted to accumulate, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of the concentration requires the use of boiler water blowdown.

#### 1. TYPES OF BLOWDOWN

There are two principal types of blowdown: intermittent manual blowdown, and continuous blowdown.

#### Intermittent Manual Blowdown

Manual or sludge blowdown is necessary for the operation of the boiler regardless of whether or not continuous blowdown is employed.

The blowdown tappings are located at the bottom or lowest part of the boiler in order to lower the dissolved solids in the pressure vessel water, and to remove a portion of the sludge that accumulates in the lower part of the vessel.

Equipment generally consists of a quick opening valve and a shut-off valve. The valves and necessary piping are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

#### Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping and is the continuous removal of concentrated water.

The surface blow-off opening, when furnished, is on the top center line of the pressure vessel. It is provided with an internal collecting pipe terminating slightly below the working water level for the purpose of skimming surface sediment, oil or other impurities from the surface of the pressure vessel water.

A controlled-orifice valve is used to allow a continual, yet controlled, flow of concentrated water.

#### WATERSIDE CARE AND REQUIREMENTS

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with the test analysis.

The flow control valve and piping are generally provided by others. All piping must be to a safe point of discharge.

#### Frequency of Manual Blowdown

When continuous blowdown is utilized, manual blowdown is primarily used to remove suspended solids or sludge. The continuous blowdown removes sediment and oil from the surface of the water along with a prescribed amount of dissolved solids.

When surface or continuous blowdown is not utilized, manual blowdown is used to control the dissolved or suspended solids in addition to the sludge.

In practice, the valve(s) of the bottom blowdown are opened periodically in accordance with an operating schedule and or chemical control tests. From the standpoint of control, economy and results, frequent short blows are preferred to infrequent lengthy blows. The length and frequency of the blwdown is particularly important when the suspended solids content of the water is high. With the use of frequent short blows a more uniform concentration of the pressure vessel water is maintained.

In cases where the feedwater is exceptionally pure, or where there is a high percentage of return condensate, blowdown may be employed less frequently since less sludge accumulates in the pressure vessel. When dissolved and or suspended solids approach or exceed predetermined limits, manual blowdown to lower the concentrations is required

It is generally recommended that a steam boiler be filted down at least once in every eight-hour period, but frequency may vary depending upon water and operating conditions. The blowdown amounts and schedule should be recommended by your local Cleaver-Brooks authorized representative.

A hot water boiler does not normally include openings for surface blowdown and bottom blowdown since blowdowns are seldom practiced. The need remains to be alert to system water losses and corresponding amount of raw water makeup. A water meter is recommended for water make-up lines.

#### Manual Blowdown Procedure

Blowdown is most effective at a point in time when the generation of steam is at the lowest rate and feedwater input is also low, thus providing a minimum dilution of the boiler water with low concentration feedwater.

Be sure the blow-off piping and tank, if used, are an proper operating condition. Discharge vents should be clear of obstruction, and the waste should be piped to a point of safe discharge.

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Valves will vary depending upon pressure involved and make or manufacturer. If seatless valves are installed, follow the manufacturer's recommendations.

If a quick opening valve and globe type of slow opening valve are in combination, the former is normally opened first and closed last with blow down accomplished with the globe or slow opening valve.

When opening the second or downstream valve, crack it slightly to allow the lines to warm, then continue opening slowly.

#### **A** CAUTION

Do not pump the lever action valve open and closed, as water hammer is apt to break the valve bodies or pipe fittings. Failure to follow these instructions could cause damage to the equipment.

The length of each blow should be determined by actual water analysis. Lowering the water in the gauge glass approximately 1/2" is often acceptable as a guide to adequate blow. However, lowering the water 1/2" should not be interpreted as a rule since water analysis procedures should prevail. If the glass cannot be viewed by the party operating the valve, another operator should watch the glass and direct the valve operator.

Close the downstream (slow opening) valve first and as fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly.

Under no circumstances should a blow-off valve be left open and the operator should never leave until the blowdown operation is completed and the valves are closed.

### H. PERIODIC INSPECTION

Insurance regulations or local laws will require a periodic inspection of the pressure vessel by an authorized inspector. Sufficient notice is generally given to permit removal of the boiler from service and preparation for inspection.

# **A** WARNING

To avoid the hazard of electrical shock, use a low voltage flashlight during an internal inspection. Preferably, inspectors should work in pairs. Failure to follow these instructions could result in serious personal injury or death.

When shutting down the boiler, the load should be reduced gradually and the pressure vessel cooled at a rate that avoids

damaging temperature differential that can cause harmful stresses. Vessels should not normally be drained until all pressure is relieved - again to prevent uneven contraction and temperature differentials that can cause expanded tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces. Some heat, however, may be desirable to dry out the interior of the boiler.

If the internal inspection is being made at the request of an authorized inspector, it is well to ask the inspector observe the conditions prior to cleaning or flushing of waterside surfaces.

Be certain that a supply of manhole and handhole gaskets is available, along with any other gaskets or items needed to place the unit back into operation after inspection.

Have available information on the boiler design, dimensions, generating capacity, operating pressure or temperature, time in service, defects found previously, and any repairs or modifications. Also have available for reference records of previous inspections.

Be prepared to perform any testing required by the inspector including a hydrostatic test.

After proper cooling and draining of the vessel, flush out the waterside with a high pressure water hose. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion and leakage.

The fireside surface should also be thoroughly cleaned so that metal surfaces, welds, joints, tube ends, fittings and any previous repairs can be readily checked.

Be sure that steam valves, and valves to expansion tank (hot water), feedwater valves, blow-off valves, all fuel valves, valves to expansion tank, and electrical switches are shut off prior to opening handholes, manhole and front or rear doors. Adequately vent the pressure vessel prior to entry.

Clean out the low-water cutoff piping, the water level controls and cross-connecting pipes. Replace the water gauge glass and clean out the water cocks. Also check and clean the drain and the blowdown valves and piping.

Check all water and steam piping and valves for leaks, wear, corrosion, and other damage. Replace or repair as required.

# I. PREPARATION FOR EXTENDED LAY-UP

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. Special attention must be given to idle boilers so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

Too many conditions exist to lay down definite rules. There are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better

method depending upon circumstances in the particular installation.

Whichever method is used, common sense dictates a periodic recheck of fireside and waterside conditions during lay-up to allow variations from the above methods for special area or job-site conditions.

Swing open the boiler head at the stack end of the unit to prevent flow of warm, moist air through the boiler tubes.

Although pollution control regulations may continue to limit the permissible sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shut town. Dorman periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during cooling. Moisture and any sulphur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid will be serious enough to cat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

The condition does not generally occur during normal firing operation, because the high temperature of operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gases from falling below the dew point.

At the start of lay-up, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, tube sheets and other fireside surfaces. Brushing will generally suffice. Sweep away or vacuum any accumulation. The fireside surfaces may be flushed with water. However, all moisture must be eliminated after flushing and the surface dried by blowing air or applying some form of heat. It is good practice to protect the cleaned surfaces by coating them with an anti-corrosive material to prevent rust.

To prevent condensation from forming in the control cabinet, keep the control circuit energized. For extended lay-up periods, especially where high humidity or large swings in ambient temperature occur, the program relay should be removed and stored in a dry atmosphere.

Dry storage is generally employed when the boiler will be out of service for a significant period of time, or where freezing temperatures may exist. In the dry storage method the boiler must be thoroughly dried because any moisture would cause corrosion. Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture-absorbing materials such as quick lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume) on trays inside the vessel. Fireside surfaces may be coated with an anti-corrosive material, or grease or tar paint. Refractorics should be brushed clean and wash-coated. All openings to the pressure vessel, such as manhole and handholes, should be shut tightly. Feedwater and steam valves should be closed.

Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in stand-by condition or in cases where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must again be taken to protect metal surfaces. Variables preclude definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and re-filled to overflowing with treated water. If deaerated water is not available, the unit should be fired to boil the water for a short period of time. Additional chemicals may be suggested by your local Cleaver-Brooks authorized representative to minimize corrosion. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used to pressurize the vessel. Fireside surfaces must be thoroughly cleaned and refractory should be wash-coated.

# CHAPTER 4 SEQUENCE OF OPERATION

A. General	4-
B. Circuit And Interlock Controls	
C. Sequence Of Operation - Oil Or Gas	
D. Flame Loss Sequence	

#### A. GENERAL

Chapter 4 outlines the electrical sequencing of various controls through the pre-purge, ignition, run, and shutdown cycles of the burner.

The program relay establishes the sequence of operation and directs the operation of all other controls and components to provide an overall operating sequence.

Note: The make or model of the program relay provided will vary depending upon job specifications. The following sequence applies regardless of the make or model. Please refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation.

Abbreviations for the various electrical components are listed in Figure 4-1. The sequences outlined in Chapter 4 employ specific nomenclature to aid in applying the text to the wiring diagram.

The burner and control system are in starting condition when the following conditions exist:

- Boiler water is up to the correct level, closing the lowwater cutoff switch.
- The low-water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cutoff setting.
- · All applicable limits are correct for burner operation.
- · The load demand light glows.

All entrance switches are closed and power is present at the line terminals of:

- · Blower motor starter
- Air compressor motor starter (if provided)
- Oil heater relay (if provided)
- Oil pump motor starter (if provided).

The sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the program relay. Chapters 6 and 7 contain operating instructions and specific information on setting and adjusting the controls.

# B. CIRCUIT AND INTERLOCK CONTROLS

The burner control circuit is a two-wire system designed for 115 Vac, 60 Hz, single-phase power.

The electrical portion of the boiler is made up of individual circuits with controls that are wired in a manner designed to provide a safe workable system. The program relay provides connection points for the interconnection of the various circuits.

The controls used vary depending upon the fuel oil or gas and the specific requirement of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. The circuits and controls normally used in the circuits follow and are referred to in the following sequence of operation.

#### Limit Circuit:

- Burner switch (BS)
- Operating limit control (OLC) pressure or temperature
- · High limit control (HLC) pressure or temperature
- Low-water cutoff (LWCO)
- Gas-oil selector switch (GOS) (Combination burner only)
- Oil drawer switch (ODS)-Oil burner
- Low oil temperature switch (LOTS) (Nos. 5 and 6 oil only)
- Low gas pressures switch (LGPS)
- High gas pressure switch (HGPS)
- LE Proximity switch interlock

- · Fuel valve interlock circuit
- Main gas valve auxiliary switch (MGVAS)
- Oil valve auxiliary switch (OVAS)

#### Blower Motor Starter Circuit

- Blower motor starter (BMS)
- Air compressor motor starter (ACMS) (if provided)
- Air purge valve (APV) (Nos. 5 or 6 oil only)

#### Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)
- · Atomizing air proving switch (AAPS) (if provided)

#### Low Fire Proving Circuit

• Low fire switch (LFS)

#### Pilot Ignition Circuit

- · Gas pilot valve (GPV)
- Ignition transformer (IT)
- · Gas pilot vent valve (GPVV) (if provided)

#### Flame Detector Circuit

- Flame detector (FD)
- Main fuel valve circuit
- Main gas valve (MGV)
- Main gas vent valve (MGVV) (if provided)
- Oil valve (OV)
- Main fuel valve light (FVL)

#### Firing Rate Circuit

- Damper motor transformer (DMT)
- Modulating damper motor (MDM)
- Manual-automatic switch (MAS)
- · Manual flame control (MFC)
- Modulating control (MC)

To comply with requirements of insurance underwriters such as Factory Mutual (FM), Industrial Risk Insurers (IRI) or others, additional interlock-devices may be used in addition to the circuits mentioned in section B.

#### High Fire Proving Circuit

• High fire switch (HFS)

#### Running Interlock and Limit Circuit

- Low oil pressure switch (LOPS)
- · High oil pressure switch (HOPS)
- High oil temperature switch (HOTS)
- Auxiliary low-water cutoff (ALWCO)

# C. SEQUENCE OF OPERATION - OIL OR GAS

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

The following sequence occurs with power present at the program relay (PR) input terminals and with all other operating conditions satisfied.

Pre-Purge Cycle - When the burner switch (BS) is turned "on," and controls wired in the "limit" and "fuel valve interlock" circuits are closed and no flame signal is present, the "blower motor start circuit" is powered energizing the blower motor starter (BMS). The load demand light (LDL) turns on. When firing oil, the air compressor motor starter (ACMS) (if provided) is also powered. Air purge valve (APV) (Nos. 5 and 6 oil only) remains deenergized.

At the same time, the program relay signals the modulating damper motor (MDM) to open the air damper. The damper begins to open and drives to its full open or high fire position. Opening the damper motor allows a flow of purging air through the boiler prior to the ignition cycle.

On certain boilers the circuitry will include a high fire switch (HFS). The purpose of the switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle. In this instance, the "high fire proving circuit" is utilized.

The controls wired into the "running interlock circuit" must be closed within 10 seconds after the start sequence. In the event any of the controls are not closed at this time, or if they subsequently open, the program relay will go into a safety shutdown.

At the completion of the high fire purge period, the program relay signals the modulating damper motor (MDM) to drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete the "low fire proving circuit." The sequence will stop and hold until the modulating damper motor (MDM) has returned to the low fire position and the contacts of the low fire switch (LFS) are closed. Once the low fire switch is closed, the sequence is allowed to continue.

Note: The ignition trial cannot be started if flame or a flame simulating condition is sensed during the pre-purge period. A safety shutdown will occur if flame is sensed at this time.

**Ignition Cycle** - The ignition transformer (IT) and gas pilot valve (GPV) are energized from the appropriate pilot ignition terminal.

Note: An oil-fired burner may be equipped with an oil pilot rather than a gas pilot. The ignition sequence of both is identical.

The pilot flame must be established and proven by the flame detector (FD) within a 10 second period in order for the ignition cycle to continue. If for any reason this does not happen, the system will shut down and safety lockout will occur.

Note: Depending upon the requirements of the regulatory body, insurer or fuel being burned, either the 10 or 15 second pilot ignition terminal may be used. Both provide the same function but differ in time interval allowed for proving main flame ignition. Refer to the boiler wiring diagram.

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized and the main fuel valve light (FVL) in the panel is lighted. The main flame is ignited and the trial period for proving the main flame begins. It lasts 10 seconds for light oil and natural gas, and 15 seconds for heavy oil. At the end of the proving period, if the flame detector still detects main flame, the ignition transformer and pilot valve are deenergized and pilot flame is extinguished.

Note: If the main flame does not light, or stay lit, the fuel valve will close. The safety switch will trip to lock out the control. Refer to flame loss sequence (section D) for description of action.

# **A** WARNING

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could result in serious personal injury or death

Run Cycle - With main flame established, the program relay releases the modulating damper motor (MDM) from its low fire position to control by either the manual flame control (MFC) or the modulating control (MC), depending upon the position of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

With the manual-automatic switch (MAS) set at automatic, subsequent modulated firing will be at the command of the modulating control (MC), which governs the position of the modulating damper motor (MDM). The air damper and fuel

valves are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

Note: Normal operation of the burner should be with the switch in the manual-automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual position at other than low fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. Excess air flow subjects the pressure vessel metal and refractory to undesirable conditions. The effectiveness of nozzle purging is lost on a No. 6 oil burner.

The burner starting cycle is now complete. The (LDL) and (FVL) lights on the panel remain lit. Demand firing continues as required by load conditions.

Burner Shudown-Post Purge - The burner will fire until steam pressure or water temperature in excess of demand is generated. With modulated firing, the modulating damper motor (MDM) should return to the low fire position before the operating limit control (OLC) opens. When the limit control circuit is opened, the following sequence occurs:

The main fuel valve circuit is deenergized, causing the main fuel valve (MGV) or (OV) to close. The flame is extinguished. The control panel lights (LDL) and (FVL) are turned off. The blower motor continues to run to force air through the boiler for the post purge period.

On a No. 6 oil burner, the air purge valve (APV) is powered from the blower motor start circuit via the contacts of the air purge relay (APR) to provide an air purge of the oil nozzle. The damper motor returns to the low fire position if it is not already in that position.

The blower motor start circuit is deenergized at the end of the post purge cycle and the shutdown cycle is complete.

The program relay is now ready for subsequent recycling, and when steam pressure or water temperature drops to close the contacts of the operating control, the burner again goes through its normal starting and operating cycle.

### D. FLAME LOSS SEQUENCE

The program relay will recycle automatically each time the operating control closes, or after a power failure. It will lockout following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the prepurge period.

The control will prevent start-up or ignition if limit circuit controls or fuel valve interlocks are open. The control will lock out upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit.

# **WARNING**

The lockout switch must be manually reset following a safety shutdown. The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could result in serious personal injury or death.

#### 1. No pilot flame.

The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately deenergized and the pilot valve closes, the reset switch lights and lockout occurs immediately.

The blower motor will continue to operate. The flame failure light and the alarm bell (optional) are energized 10 seconds later.

The blower motor will be deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

#### 2. Pilot but no main flame.

When the pilot flame is proven, the main fuel valve circuit is energized. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 or 15 seconds later. The flame detecting circuit will respond to deenergize the main fuel valve circuit within 2 to 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

#### 3. Loss of flame.

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay will trip within 2 to 4 seconds to deenergize the fuel valve circuit and shut off the fuel flow. The reset switch lights and lockout occurs immediately. The blower motor continues operation. The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

If the burner will not start, or upon a safety lockout, the trouble shooting section in the operating manual and the

technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the manual and this bulletin.

Knowledge of the system and its controls will make troubleshooting much easier. Costly down time or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember, a safety device, for the most part, is doing its job when it shuts down or refuses to operate. <u>Never</u> attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay is recommended to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame.

MNEMONIC	DESCRIPTION
	Α
Α	Amber (Color Of Pilot Light)
AAFL	Atomizing Air Failure Light
AAFR	Atomizing Air Failure Relay
AAPL	Atomizing Air Proven Light
AAPS	Atomizing Air Proving Switch
AAPS-B	Atomizing Air Proving Switch- Burner
AAPS-C	Atomizing Air Proving Switch- Compressor
AASS	Atomizing Air Selector Switch
AB	Alarm Bell
ACCR	Air Compressor Control Relay
ACM	Air Compressor Motor
ACMCB	Air Compressor Motor Circuit Breaker
ACMF	Air Compressor Motor Fuses
ACMS	Air Compressor Motor Starter
ACMSI	Air Compressor Motor Starter Interlock
AH	Alarm Hom
ALFR	Assured Low Fire Relay
ALWCO	Auxiliary Low Water Cutoff
AM	Ammeter
AMS	Atomizing Media Switch
AOV	Auxiliary Oil Valve
APR	Air Purge Relay
APV	Air Purge Valve
AR	Alarm Relay
AS	Auxiliary Switch (Suffix)
ASR	Alarm Silencing Relay
ASS	Alarm Silencing Switch
ASV	Atomizing Steam Valve
AT	Annunciator Transformer
AWCBDS	Auxiliary Water Column Blowdown Switch
	В
3	Blue (Color of Pilot Light)
3C	Bias Control
BDCS	Breeching Damper Closed Switch
BDOS	Breeching Damper Open Switch
BDRS	Blowdown/Reset Switch
BFPL	Boiler Feed Pump Light
BFPM	Boiler Feed Pump Motor
BEPMCB	Boiler Feed Pump Motor Circuit Breaker
SFPMF	Boiler Feed Pump Motor Fuses
SFPMS	Boiler Feed Pump Motor Starter
SFPS	Boiler Feed Pump Switch
FTS	Back Flow Temperature Switch
BHS	Boiler - Header Switch
BIOL	Boiler in Operation Light
IOR	Boiler In Operation Relay
M	Blower Motor
МСВ	Blower Motor Circuit Breaker
MCR	Blower Motor Control Relay
MF	Blower Motor Fuses
	Blower Motor Power Relay
	Blower Motor Purge Switch
	Blower Motor Relay
	Blower Motor Starter
_	Biower Motor Starter Interlock
	Boiler Master Selector Switch

BS Burner Switch BSS Boiler Selector Switch BWPM Booster Water Pump Motor BWT Booster Water Thermostat  C CAFL Combustion Air Failure Light CAFR Combustion Air Failure Belay CAP Capacitor CAPS Combustion Air Proving Switch CCCB Control Circuit - Circuit Breaker CCF Control Circuit Transformer CIPL Changeover In Progress Light CL Canopy Light Switch COPS Changeover Pressure Switch COPS Changeover Pressure Switch COPS Changeover Time Delay COPD Changeover Time Delay CPOL Control Power on Light CR Control System Selector Switch CWPM Circulating Water Pump Motor Circuit Breaker CWPMF Circulating Water Pump Motor Starter CWPMS Circulating Water Pump Switch CWSV Cooling Water Solenoid Valve  D D Denotes Digester Gas Equipment (Prefix) DCVM Direct Current Voltmeter DG Draft Gauge DGHPV Digester Gas Housing Purge Valve DHWC Deaerator High Water Control DHWC Deaerator High Water Control DHWC Deaerator Low Water Relay DISC Disconnect (Entrance Switch) DLWC Deaerator Low Water Relay DMD Denotes Digester Gas Equipment (Prefix) DLWC Deaerator Low Water Relay DISC Disconnect (Entrance Switch) DLWC Deaerator Low Water Relay DMD Damper Motor Transformer DMT Damper Motor Transformer DMS Day-Night Switch DDD Deaenergization (Timer) DDD Deaener	MNEMONIC	DESCRIPTION
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CAFR Combustion Air Failure Relay  CAP Capacitor  CAPS Combustion Air Proving Switch  CCCB Control Circuit - Circuit Breaker  CCF Control Circuit Fuse  CCF Control Circuit Fuse  CCGR Control Circuit Transformer  CIPL Changeover In Progress Light  CL Canopy Light  CLS Canopy Light Switch  COPS Changeover Pressure Switch  COPS Changeover Pressure Switch  COR Changeover Relay  COTD Changeover Time Delay  COTD Changeover Time Delay  COTD Control Power on Light  CR Control Relay  CSSS Control System Selector Switch  CWPM Circulating Water Pump Motor Circuit Breaker  CWPMF Circulating Water Pump Motor Starter  CWPMS Circulating Water Pump Motor Starter  CWPMS Circulating Water Pump Motor Starter  CWPMS Circulating Water Pump Switch  CWPR Circulating Water Pump Switch  CWSV Cooling Water Solenoid Valve  D  D  D Denotes Digester Gas Equipment (Prefix)  DCVM Direct Current Voltmeter  DG Draft Gauge  DGHPV Digester Gas Housing Purge Valve  DHWC Deaerator High Water Control  DHWL Deaerator High Water Control  DHWL Deaerator Low Water Relay  DISC Disconnect (Entrance Switch)  DLWC Deaerator Low Water Relay  DM Damper Motor  DMT Damper Motor  DMT Damper Motor  DMT Damper Motor  DMS Day-Night Switch  DODE Delay On Deenergization (Timer)  DOS Dor Switch  E  EDS Emergency Door Switch	0.45	
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CWSV Cooling Water Solenoid Valve  D Denotes Digester Gas Equipment (Prefix)  DCVM Direct Current Voltmeter  DG Draft Gauge  DGHPV Digester Gas Housing Purge Valve  DHWC Deaerator High Water Control  DHWL Deaerator High Water Light  DHWR Deaerator High Water Relay  DISC Disconnect (Entrance Switch)  DLWC Deaerator Low Water Control  DLWL Deaerator Low Water Light  DLWR Deaerator Low Water Relay  DM Damper Motor  DMT Damper Motor Transformer  DNS Day-Night Switch  DODE Delay On Deenergization (Timer)  DOS Damper Positioning Switch  DS Door Switch  E  EDS Emergency Door Switch		
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ESS Emergency Stop Switch	70	
Emergency Stop Switch	LUS E	mergency Door Switch
TM Elapsed Time Meter	IM E	lapsed Time Meter
F		
ADM Fresh Air Damper Motor		
ADR Fresh Air Damper Relay		
D Flame Detector		lame Detector

FD Flame I

MNEMONI	DESCRIPTION
FDJB	Flame Detector Junction Box
FDPS	Flow Differential Pressure Switch
FFA	Flame Failure Alarm
FFL	Flame Failure Light
FFR	Flame Failure Relay
FGR	Flue Gas Recirculation
FGRCDTD	Flue Gas Recirculation Cool Down Time Delay
FGRCPS	Flue Gas Recirculation Cam Position Switch
FGRFM	Flue Gas Recirculation Fan Motor
FGRFMS	Flue Gas Recirculation Fan Motor Starter
FGRFMSI	Flue Gas Recirculation Fan Motor Starter Interlock
<b>FGRMVLS</b>	Flue Gas Recirculation Manual Valve Limit Switch
FGRTD	Flue Gas Recirculation Time Delay
FORS	First Out Reset Switch
FPM	Feed Pump Motor
FPMS	Feed Pump Motor Starter
FPR	Feed Pump Relay
FPS	Feed Pump Switch
FRI	Firing Rate Interface
FRP	Firing Rate Potentiometer (O2 Trim)
FS	Flow Switch
FSS	Fuel Selector Switch
FSSM	Flame Signal Strength Meter
FVEL	Fuel Valve Energized Light
FVL	Fuel Valve Light
FVR	Fuel Valve Belay
FWC	Feed Water Control
FWVT	Feed Water Valve Transformer
	G
	Green (Color Of Pilot Light)
GGL	Gauge Glass Light
GOL	Gas Operation Light
GOR	Gas-Oil Relay
GOS	Gas-Oil Switch
GOR	Gas-Oil Relay
GPS	Gas Pressure Sensor
GPV	Gas Pilot Valve
SPVV	Gas Pilot Vent Valve
ar v v	Gas Relay
GSSV	Gas Sensor Solenoid Valve
SVEL	Gas Valve Energized Light
SVTS	
	Gas Valve Test Switch
HATC	H High Ambient Tomoret Control
	High Ambient Temperature Control
HBWTC	High Boiler Water Temperature Control
IFAV	High Boiler Water Temperature Light
FGV	High Fire Air Valve
	High Fire Gas Vaive
IFL	High Fire City of
IFOV	High Fire Oil Valve
IFPS	High Furnace Pressure Switch
	High Fire Switch
	High Fire Switch - Air
	High Gas Pressure Light
GPR	High Gas Pressure Relay
GPS	High Gas Pressure Switch
HFL	Header High Fire Light

H/LWA High Low Water A HLC High Limit Control HLFC High-Low Fire Con HLPC High Limit Pressur HLTC High Limit Temper HMC Header Modulatin HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	ntrol re Control rature Control g Control Light Relay
HLC High Limit Control HLFC High-Low Fire Cot HLPC High Limit Pressur HLTC High Limit Temper HMC Header Modulatin HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	ntrol re Control rature Control g Control Light Relay
HLPC High Limit Pressur HLTC High Limit Temper HMC Header Modulating HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	re Control rature Control g Control Light Relay
HLPC High Limit Pressur HLTC High Limit Temper HMC Header Modulating HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	re Control rature Control g Control Light Relay
HLTC High Limit Temper HMC Header Modulating HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	rature Control g Control Light Relay
HMC Header Modulating HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	g Control Light Relay
HOPL High Oil Pressure HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	Light Relay
HOPR High Oil Pressure HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	Relay
HOPS High Oil Pressure HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	Switch
HOLC Header Operating HOTL High Oil Temperat HOTR High Oil Temperat	
HOTL High Oil Temperat HOTR High Oil Temperat	Limit Control
HOTR High Oil Temperat	
HOTS High Oil Temperat	
HPCO High Pressure Cut	off
HSPC High Steam Press	
HSPL High Steam Press	ure Light
HSPR High Steam Press	
HSTC High Stack Tempe	
HSTL High Stack Tempe	
HSTS High Stack Tempe	
HWAR High Water Alarm	Relay
HWC High Water Contro	
HWCO High Water Cutoff	
HWL High Water Light	
The Light	T
(I.C.) Instantaneously Cit	
(I.O.) Instantaneously Op	
IL Ignition Light	
INT Interval (Timer)	
IR Ignition Relay	
IT Ignition Transforme	er
	J
JPP Jackshaft Position I	
	L
LAMPS Low Atomizing Med	dia Pressure Switch
LASPS Low Atomizing Stea	am Pressure Switch
LDL Load Demand Light	
LDPS Low Differential Pre	
LDS Low Draft Switch	
LFAV Low Fire Air Valve	
LFGV Low Fire Gas Valve	
LFHTD Low Fire Hold Time	
LFL Low Fire Light	
FOV Low Fire Oil Valve	
LFPS Low Fire Pressure S	Switch
FR Low Fire Relay	
FS Low Fire Switch	
FS-A Low Fire Switch - Ai	r
FS-F Low Fire Switch - Fu	
FS-G Low Fire Switch - G	
FS-O Low Fire Switch - Oi	
FTC Low Fire Temperatu	
.GPL Low Gas Pressure L	ight
GPR Low Gas Pressure F	
GPS Low Gas Pressure S	
IAPS Low Instrument Air F	
LPC Low Limit Pressure (	Control

Figure: 4-1 Electrical Nomenclature (Continued)

LLPR Low Limit Pressure Relay  LLR Lead Lag Relay  LLTC Low Limit Temperature Control  LLTR Low Limit Temperature Relay  LOPL Low Oil Pressure Light  LOPR Low Oil Pressure Switch  LOPR Low Oil Pressure Switch  LOPR Low Oil Temperature Light  LOPR Low Oil Temperature Relay  LOPS Low Oil Temperature Relay  LOPS Low Oil Temperature Relay  LOTS Low Oil Temperature Switch  LPAPS Low Plant Air Pressure Switch  LPAPS Low Pressure Switch  LPAPS Low Pressure Switch  LPAPS Low Steam Pressure Control  LPSP Low Steam Pressure Control  LSPAR Low Steam Pressure Light  LSPC Low Steam Pressure Relay  LSPC Low Steam Pressure Switch  LSPR Low Steam Pressure Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LWA Low Water Alarm  LWAR Low Water Alarm Relay  LWCO Low Water Flow Light  LWL Low Water Flow Light  LWL Low Water Relay  LWRR Low Water Relay  LWRR Low Water Reset Relay  MMA Milliamp  MAS Manual - Automatic Switch  MAM Micrometer  MC Modulating Damper Motor  MDMAS Manual Control Switch  MDM Modulating Damper Motor  MDMAS Modulating Damper Motor  MDMAS Modulating Damper Motor Auxiliary Switch  MFC Manual Flame Control (Potentiometer)  MFGRTS Minimum Flue Gas Recirculation Temperature Switch  MFV Motorized Feed Water Valve  MGV Main Gas Valve Light  MFV Motorized Feed Water Valve  MGV Main Gas Valve Houtiliary Switch  MGVAS Main Gas Valve Light  MFWV Motorized Feed Water Valve  MGVAS Main Gas Valve Auxiliary Switch  MGVAS Main Gas Valve Light  MFWW Motorized Feed Water Valve  MGVAS Main Gas Valve Loptin  MFWV Motorized Feed Water Valve  MGVAS Main Gas Valve Dentrol  MOM) Momentary  MOV Main Gas Valve Energized Light  MGVA Main Gas Valve Auxiliary Switch  MGVB Main Gas Valve Auxiliary Switch  MGVB Main Gas Valve Control  MOMON Momentary  MOV Main Gas Salve Control  MOWO Main Oil Valve Energized Light  MRD Manual Reset  MTC Modulating Temperature Control  MVA Make-Up Valve Actuator  Normally Open  N.C.) Normally Open	MNEMONI	C DESCRIPTION
LLR Lead Lag Relay  LLTC Low Limit Temperature Control  LLTR Low Cimit Temperature Relay  LOPL Low Oil Pressure Relay  LOPS Low Oil Pressure Relay  LOPS Low Oil Pressure Relay  LOPS Low Oil Pressure Switch  LOTL Low Oil Temperature Eight  LOTR Low Oil Temperature Switch  LPAPS Low Plant Air Pressure Switch  LPAPS Low Pressure Cutoff  LPS Low Pressure Switch  LPS Low Steam Pressure Light  LSPAR Low Steam Pressure Light  LSPAR Low Steam Pressure Light  LSPAR Low Steam Pressure Switch  LSPAR Low Steam Pressure Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LWA Low Water Alarm  LWAR Low Water Alarm Relay  LWCO Low Water Cutoff  LWFL Low Water Flow Light  LWL Low Water Flow Light  LWL Low Water Relay  LWRR Low Water Reset Relay  MMA Milli-amp  MAS Manual - Automatic Switch  MAM Micrometer  MC Modulating Damper Motor  MDMAS Manual Control Switch  MMOM Modulating Damper Motor Auxiliary Switch  MFG Manual Flame Control (Potentiometer)  MFGRTS Minimum Flue Gas Recirculation Temperature St  MFGRTS Minimum Flue Gas Recirculation Temperature St  MFGWV Main Gas Valve Light  MFWV Motorized Feed Water Valve  MGV Main Gas Valve Energized Light  MGV Main Gas Valve Energized Light  MGVAS Main Oil Valve  MCOVAS Main Oil Valve Auxiliary Switch  MGVAS Main Gas Valve Energized Light  MGVAS Main Gas Valve Energized Light  MGVAS Main Oil Valve Description Light  MGPC Modulating Pressure Control  MOM) Momentary  MOWAS Main Oil Valve Energized Light  MGPC Modulating Pressure Control  MOM Manual Positioning Potentiometer  MR) Denotes Natural	I PR	
LLTC Low Limit Temperature Control LLTR Low Limit Temperature Relay LOPL Low Oil Pressure Light LOPR Low Oil Pressure Relay LOPS Low Oil Pressure Relay LOPS Low Oil Pressure Switch LOTL Low Oil Temperature Eight LOTR Low Oil Temperature Eight LOTR Low Oil Temperature Switch LOTR Low Oil Temperature Switch LOTR Low Oil Temperature Switch LOTS Low Oil Temperature Switch LPAPS Low Plant Air Pressure Switch LPAPS Low Pressure Cutoff LPS Low Pressure Switch LPCO Low Pressure Switch LPCO Low Steam Pressure Light LSPAR Low Steam Pressure Light LSPAR Low Steam Pressure Eight LSPAR Low Steam Pressure Switch LSPAR Low Steam Pressure Switch LSPAR Low Steam Pressure Switch LTS Lamp Test Switch LTS Lamp Test Switch LTS Lamp Test Switch LWA Low Water Alarm LWAR Low Water Alarm Relay LWCO Low Water Cutoff LWFL Low Water Flow Light LWL Low Water Flow Light LWL Low Water Relay LWRR Low Water Reset Relay MMA Milli-amp MAS Manual - Automatic Switch MMA Milli-amp MAS Manual Control Switch MMOM Modulating Damper Motor MDMAS Modulating Damper Motor Auxiliary Switch MMCS Manual Flame Control (Potentiometer) MPGATS Minimum Flue Gas Recirculation Temperature St MFGRTS Minimum Flue Gas Recirculation Temperature St MFGRTS Minimum Flue Gas Recirculation Temperature St MFGWV Main Gas Valve Auxiliary Switch MGVV Main Gas Valve Light MFWV Motorized Feed Water Valve MGV Main Gas Valve Light MGVV Main Gas Valve Control MOM) Momentary MOV Main Gas Valve Auxiliary Switch MGVEL Main Gil Valve Auxiliary Switch MGVEL Main Gil Valve Energized Light MGVEL Main Gil Valve Energized Light MFC Modulating Pressure Control MOM) Momentary MIN Manual Positioning Potentiometer MPC Manual Positioning Potentiometer MPC Manual Positioning Potentiometer MR) Manual Position		
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LOPS Low Oil Pressure Switch  LOTL Low Oil Temperature Light  LOTR Low Oil Temperature Relay  LOTS Low Oil Temperature Switch  LPAPS Low Plant Air Pressure Switch  LPAPS Low Pressure Cutoff  LPS Low Pressure Switch  LSPAR Low Steam Pressure Alarm Relay  LSPC Low Steam Pressure Light  LSPL Low Steam Pressure Light  LSPL Low Steam Pressure Relay  LSPS Low Steam Pressure Switch  LSPS Low Steam Pressure Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LTS Lamp Test Switch  LWA Low Water Alarm  LWAR Low Water Alarm Relay  LWCO Low Water Flow Light  LWC Low Water Flow Light  LWL Low Water Flow Light  LWR Low Water Relay  LWRR Low Water Relay  LWRR Low Water Relay  LWRR Manual - Automatic Switch  MAM Mili-amp  MAS Manual - Ontrol Switch  MODM Modulating Damper Motor  MODMAS Modulating Damper Motor Auxiliary Switch  MFC Manual Flame Control (Potentiometer)  MFGRTS Minimum Flue Gas Recirculation Temperature Switch  MFC Manual Flame Control (Potentiometer)  MFGRTS Minimum Flue Gas Recirculation Temperature Switch  MFWW Motorized Feed Water Valve  MGVAS Main Gas Valve  MGVAS Main Gas Valve Energized Light  MGCV MGCV MGCV WGCV MGCV MGCV MGCV MGCV MG		
LOTL LOW Oil Temperature Light LOTR LOW Oil Temperature Relay LOTS LOW Oil Temperature Switch LPAPS LOW Plant Air Pressure Switch LPCO LOW Pressure Cutoff LPS LOW Steam Pressure Alarm Relay LSPC LOW Steam Pressure Light LSPA LOW Steam Pressure Light LSPA LOW Steam Pressure Light LSPB LOW Steam Pressure Relay LSPB LOW Steam Pressure Switch LTS LAMP Test Switch LTS LAMP Test Switch LTS LAMP Test Switch LOW Water Alarm LOW Water Alarm LOW Water Alarm LOW Water Cutoff LWFL LOW Water Flow Light LWR LOW Water Flow Light LWR LOW Water Relay LWRR LOW Water Relay LWRR LOW Water Reset Relay MAA Milli-amp MAS Manual - Automatic Switch MAM Micrometer MC MOdulating Control MCS Manual Control Switch MMDM MODMAS Modulating Damper Motor MDMAS Modulating Damper Motor Auxiliary Switch MFC Manual Flame Control (Potentiometer) MFGRTS Minimum Flue Gas Recirculation Temperature Sw MFVL Main Fuel Valve Light MFWV Motorized Feed Water Valve MGVAS Main Gas Valve MGVAS Main Gas Valve MGVAS Main Gas Valve Energized Light MGVAS Main Oil Valve Energized Light MGPC Modulating Pressure Control MOVAS Main Oil Valve Energized Light MFC Modulating Temperature Control MGNA Manual Reset MFP		
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LSPS Low Steam Pressure Switch  LTS Lamp Test Switch  LWA Low Water Alarm  LWAR Low Water Alarm Relay  LWCO Low Water Cutoff  LWFL Low Water Flow Light  LWL Low Water Elght  LWR Low Water Relay  LWRR Low Water Reset Relay  MMA Milli-amp  MAS Manual - Automatic Switch  MAM Micrometer  MC Modulating Control  MCS Manual Control Switch  MDM Modulating Damper Motor Auxiliary Switch  MFC Manual Flame Control (Potentiometer)  MFGRTS Minimum Flue Gas Recirculation Temperature St  MFVL Main Fuel Valve Light  MFWV Motorized Feed Water Valve  MGVAS Main Gas Valve  MGVAS Main Gas Valve Energized Light  MGVU Main Gas Vent Valve  MGVU Main Gas Vent Valve  MGVU Main Gas Vent Valve  MGVU Main Gil Valve Energized Light  MGWOV Main Oil Valve Energized Light  MOW) Momentary  MOV Main Oil Valve Energized Light  MGVU Main Oil Valve Energized Light  MGVU Main Oil Valve Energized Light  MGVOV Main Oil Valve Energized Light  MGVOV Main Oil Valve Energized Light  MGVOV Main Oil Valve Energized Light  MPC Modulating Pressure Control  MOM) Momentary  MOV Main Oil Valve Energized Light  MPC Modulating Pressure Control  MR) Manual Reset  MTC Modulating Temperature Control  Normally Closed  N.C.) Normally Closed		
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LWR Low Water Relay  MMA Milli-amp  MAS Manual - Automatic Switch  MAM Micrometer  MC Modulating Control  MCS Manual Control Switch  MDM Modulating Damper Motor  MDMAS Modulating Damper Motor Auxiliary Switch  MFC Manual Flame Control (Potentiometer)  MFGRTS Minmum Flue Gas Recirculation Temperature Switch  MFVL Main Fuel Valve Light  MFWV Motorized Feed Water Valve  MGV Main Gas Valve  MGVAS Main Gas Valve Auxiliary Switch  MGVEL Main Gas Valve Energized Light  MGVV Main Gas Vent Valve  MCV Modulating Level Control  MOM) Momentary  MOV Main Oil Valve Auxiliary Switch  MOVAS Main Oil Valve Auxiliary Switch  MOVAS Main Oil Valve Energized Light  MFC Modulating Pressure Control  MPC Modulating Pressure Control  MPCB Main Power Circuit Breaker  MPP Manual Positioning Potentiometer  MR) Manual Reset  MTC Modulating Temperature Control  MVA Make-Up Valve Actuator  N  Denotes Natural Gas Equipment (Prefix)  N.C.) Normally Closed  N.C.) Normally Closed	LWL	Low Water Light
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N.C.) Normally Closed N.O.) Normally Open		
N.O.) Normally Open		
TL No Fiow Light		No Flow Light

MNEMON	DESCRIPTION
NFR	No Flow Relay
NGHPV	Natural Gas Housing Purge Valve
	0
ODA	Outlet Damper Actuator
ODM	Outlet Damper Motor
ODMAS	Outlet Damper Motor Auxiliary Switch
ODMT	Outlet Damper Motor Transformer
ODS	Oil Drawer Switch
ОН	Oil Heater
ОНСВ	Oil Heater Circuit Breaker
OHF	Oil Heater Fuses
OHR	Oil Heater Relay
OHS	Oil Heater Switch
OHT	Oil Heater Thermostat
OLC	Operating Limit Control
OLPC	Operating Limit Pressure Control
OL'S	Thermal Overloads
OLTC	Operating Limit Temperature Control
OMPM	Oil Metering Pump Motor
OMPMF	Oil Metering Pump Motor Fuse
OOL	Oil Operation Light
OPM	
	Oil Pump Motor
OPMCB	Oil Pump Motor Circuit Breaker
OPMF	Oil Pump Motor Fuses
OPMS	Oil Pump Motor Starter
OPPM	Oil Purge Pump Motor
OPR	Oll Purge Relay
OPRL	Oil Pump Running Light
OPRS	Oil Pressure Sensor
OPS	Oil Pump Switch
OPSPM	Oil Pump Supply Pump Motor
OPV	Oil Purge Vaive
OR	Oil Relay
DRV	Oil Return Valve
osov	Oil Shutoff Valve
OSPS	O2 Set Point Switch
oss	Oil Selector Switch
T	Outdoor Thermostat
OTS	Oil Temperature Sensor
OV	Oil Valve
VAS	Oil Valve Auxiliary Switch
VEL	Oil Valve Engrand Light
	Oil Valve Energized Light
<del></del>	P
AASV	Denotes Propane Gas Equipment (Prefix)
APS	Plant Air Atomizing Solenoid Valve
	Purge Air Proving Switch
C	Pump Control
CL	Purge Complete Light
CR	Pump Control Relay
FCC	Power Factor Correction Capacitor
FFL	Pilot Flame Failure Light
FFR	Pilot Flame Failure Relay
FPS	Positive Furnace Pressure Switch
HGPS	Pilot High Gas Pressure Switch
IPL	Purge in Progress Light
IS	Pilot Ignition Switch
LC	Programmable Logic Controller

Figure: 4-1 Electrical Nomenclature (Continued)

MNEMON	C DESCRIPTION
POL	Power On Light
POV	Pilot Oil Valve
PPL	Pre-Purging Light
PPR	Post Purge Relay
PPTD	Post Purge Time Delay
PR	Program Relay
PRL	Purge Ready Light
PRPTD	Pre-Purge Time Delay
PR	Program Relay
PRPTD	Per-Purge Time Delay
PS	Power Supply
PSF	Power Supply Fuse
PSS	Pump Selector Switch
PSV	Purge Solenoid Vaive
PT	Purge Timer
PTS	Pump Transfer Switch
PUCR	Purge Complete Relay
PUR	Purge Relay
	R
٦	Red (Color of Pilot Light)
RAR	Remote Alarm Relay
RATD	Remote Alarm Time Delay
RES	Resistor
RML	Run Mode Light
RMR	Release To Modulate Relay
RS -	Range Switch
RSR	Remote Start Relay
RTD	Resistance Temperature Detector
	S
BFPL	Stand By Feed Pump Light
BFPM	Stand By Feed Pump Motor
BFPMCB	Stand By Feed Pump Motor Circuit Breaker
BFPMF	Stand By Feed Pump Motor Fuses
BFPMS	Stand By Feed Pump Motor Starter
BOV	Surface Blow Off Valve
BPS	Sootblower Pressure Switch
BR	Sootblower Relay
C	Scanner
CTS	Supervisory Cock Test Switch
DL	Steam Demand Light
HT	Steam Heater Thermostat
HV	Steam Heater Valve
LCL	Safety Limits Complete Light
PIR	System Pump Interlock Relay
PS	Steam Pressure Sensor
s	Selector Switch
sc	Sequencing Step Controller
SL	Safety Shutdown Light
SR	Solid State Relay
SV .	SpanSolenoid Relay
THWC	Surge Tank High Water Control
THWL	Surge Tank High Water Light
	Surge Tank High Water Relay
	Surge Tank Low Water Control
LIVO	

MNEMONIC	DESCRIPTION
STLWR	Surge Tank Low Water Relay
	Υ
(T.C.)	Timed Closed
(T.O.)	Timed Open
TB	Terminal Block
T/C	Thermocouple
TC	Time Clock
TCR	Time Clock Relay
TD	Time Delay
TDAS	Time Delay Auxiliary Switch
TFWR	Transistorized Feedwater Relay
TPL	Transfer Pump Light
TPM	Transfer Pump Motor
ТРМСВ	Transfer Pump Motor Circuit Breaker
TPMF	Transfer Pump Motor Fuses
TPMS	Transfer Pump Motor Starter
TPS	Transfer Pump Switch
	U
JVFD	Ultra-Violet Flame Detector
	V
/	Voltmeter
/DR	Voltage Differential Relay
N	White (Color of Pilot Light)
VC	Water Column
WCBDS	Water Column Blow Down Switch
	Water Feeder
VFNL	Water Flow Normal Light
VLC	Water Level Control
VO	Denotes Waste Oil Equipment (Prefix)
VTS	Water Temperature Sensor
,	Y
	Yellow (Color of Pilot Light)

Figure: 4-1 Electrical Nomenclature (Continued)

# **CHAPTER 5**

# STARTING AND OPERATING INSTRUCTIONS

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H. IFGR Setup and Operation
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Note: If your boiler is equipped with a CB-HAWK™ boiler management control system, refer to CB-HAWK Installation, Operating and Servicing Manual No. 750-133 for specific information regarding procedures described in section A.

# A. GENERAL PREPARATION FOR START-UP, ALL FUELS

Instructions in Chapter 5 are all based upon installation being complete and all electrical, fuel, water and vent stack connections are made.

The operator should be familiar with the burner, boiler, and all controls and components. To quickly locate and identify the various controls and components mentioned in the following paragraphs, refer to the illustrations and the contents of Chapters 1, 2 and 3. Instructions for adjusting major components are given in Chapter 6 this should be reviewed prior to firing. The wiring diagram should also have been studied, along with the firing sequence outlined in Chapter 4.

# **A** WARNING

Be sure the starting instructions be read completely until they are thoroughly understood, before attempting to operate the boiler, rather than performing each operation as it is read for the first time. Failure to follow these instructions could result in serious personal injury or death.

Verify supply of fuel and proper voltage. Check for blown fuses, open circuit breakers, dropped out overloads, etc. Check reset of all starters and controls having manual reset

features. Check the lockout switch on the programmer and reset if necessary.

The boiler should be filled with water to the proper operating level using water of ambient temperature. Be sure that treated feedwater is available and used. In heating applications, the entire system should be filled and vented. Refer to Chapter 3 for water requirements. On a steam boiler, open the test valve (Figure 1-7) to vent air displaced during filling. Leave the test valve open until the escape of steam is noted after the burner is operating.

# **AWARNING**

Prior to firing a boiler, be sure that discharge piping from safety valves or relief valves, and discharge piping from all blowdown and drain valves, is piped to a SAFE point of discharge, so that discharge of hot water or steam cannot possibly cause injury. Failure to follow these instructions could result in serious personal injury or death.

Cheek all linkage for full and free movement of the damper and metering valves and cams. The cheek can be done by loosening the linkage at the damper motor connecting arm and manipulating the linkage by hand.

Check for rotation of all motors by momentarily closing the motor starter or relay. The blower impeller rotation is counter-clockwise for the CB-LE, when viewed from the front of the boiler (see Figure 5-1). The air pump rotation is clockwise when viewed from its drive end (see Figure 5-2). When operating a standard 78" boiler the fan motor and air pump should rotate counterclockwise (see Figure 5-3).

#### Chapter 5

Before operating the boiler feed pump or oil supply pump, be sure all valves in the line are open or properly positioned.

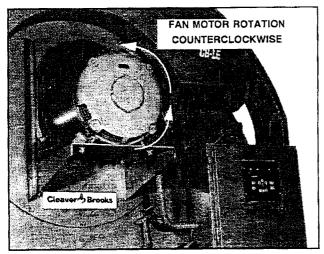


Figure: 5-1 Fan Motor CB-LE

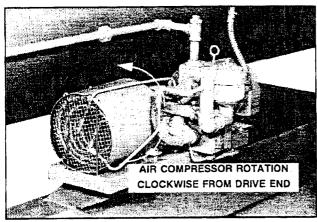


Figure: 5-2 Air Compressor

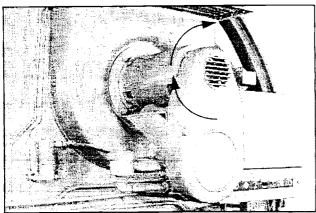


Figure: 5-3 Fan Motor and Air Pump (Standard 78")

#### STARTING AND OPERATING INSTRUCTIONS

For safety reasons, perform a final pre-startup inspection, especially checking for any loose or incomplete piping or wiring or any other situations that might present a hazard.

Note: The pressure vessel support legs are welded to mounting skids in front and secured by bolts at the rear of the pressure vessel. The bolts are tightened for shipment. When the boiler is installed, and prior to initial firing, the bolts securing the rear legs to the skid must be loosened to allow for expansion and contraction caused by differences in temperature between pressure vessel and skids and to avoid damage to the equipment.

# B. CONTROL SETTINGS - STEAM AND HOT WATER

See Chapter 6 for adjustment instructions for the following controls.

Inspect the Operating Limit Control for proper setting.

- The operating limit pressure control of a steam boiler should be set slightly above the highest desired steam pressure, but at least 10% lower than the setting of the safety valve.
- The operating limit temperature control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the High Limit Control for proper setting.

- 1. On a high pressure steam boiler, the high limit pressure control should be set approximately 10 psig above the operating limit pressure control setting, if feasible, or midway between the operating limit pressure and the safety valve setting. The setting on a low pressure steam boiler may be 2 or 3 psig above the operating limit setting, but must not exceed the safety valve setting.
- 2. On a hot water boiler, the high limit temperature control should be 5-10°F above the operating limit temperature control setting but within the limits of the design pressure of the pressure vessel.

Inspect the Modulating Control for proper setting. The control must be set and adjusted so that the modulating motor returns to low fire position before the operating limit control opens. It is further desirable to have its low point setting somewhat below the cut-in setting of the limit control so that the burner operates in low fire position for a brief period on each start rather than immediately driving to a high fire position.

Note: The settings of all the above controls may require some readjustment after the boiler is started and running for a short period. The scale settings on the controls are relatively accurate, but are principally for use as guides. Final adjustment should be based on and agree with the reading of the steam pressure gauge or the water temperature thermometer.

Inspect the Low-water Cutoff and Pump Control as well as the Auxiliary Low-water Cutoff (if equipped with this optional device). Check for freedom of float movement. Float movement can be verified by observing the level of water in the gauge glass when the water supply has been cut off either by the stopping of the feed pump or by the closing of a valve, and the restarting of the pump or opening of the valve when water is drained from the pressure vessel. The importance of proper functioning of low-water controls cannot be overemphasized. Be sure that the control and the piping is level.

The settings of controls relating to fuel, either oil or gas, are covered in subsequent sections.

In the event the boiler is equipped with optional control devices not listed here, be certain to ascertain that their settings are correct. If additional information is required, see your local Cleaver-Brooks authorized representative or contact Cleaver-Brooks.

On initial start-up or whenever the boiler is placed into operation from a "cold" start, the Manual-automatic Selector Switch should be set at "manual" and the Manual Flame Control set at "close." After the boiler is in operation and thoroughly warmed, the selector switch should be turned to "automatic," so that the burner firing rate may be controlled by the Modulating Control in accordance with load demands.

Close all power entrance switches (supplied by others).

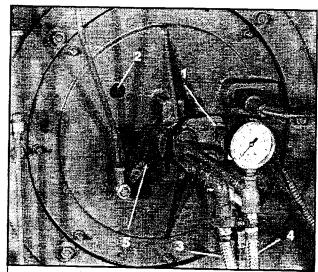
#### C. GAS PILOT

The gas pilot should be checked for satisfactory performance prior to initial firing. Follow the pilot flame adjustment instructions given in Chapter 6.

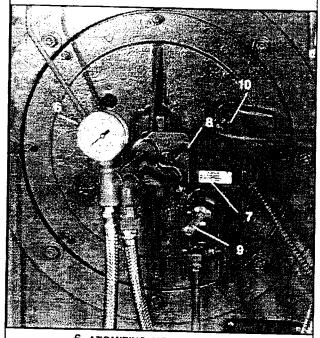
On initial starting attempts, several efforts might be required to fully bleed the pilot line. While checking pilot adjustment, observe whether the pilot flame is extinguished promptly when the burner switch is opened. A lingering flame indicates a leaking gas pilot valve, which is a condition requiring correction before proceeding.

#### D. ATOMIZING AIR

The supply and pressure of the atomizing air on an oil-fired burner should be checked. Before starting, inspect the oil pump lube oil level. Add oil if necessary to bring the level to the mid-point or slightly higher of the sight glass. Use SAE



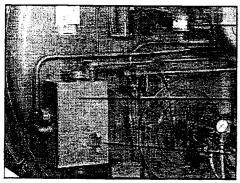
- 1. BURNER DRAWER LOCKING PIN
- 2. FLAME VIEW PORT
- 3. FUEL OIL LINE
- 4. ATOMIZING AIR LINE
- 5. MODULATING AIR DAMPER CAM



- 6. ATOMIZING AIR PRESSURE GAUGE
- 7. OIL DRAWER SWITCH
- 8. OIL DRAWER LATCH
- 9. IGNITION ELECTRODE
- 10. SCANNER

Figure: 5-4 Burner Drawer With Gun Positioned For Firing Oil.

#### STARTING AND OPERATING INSTRUCTIONS



AIR INTAKE STRAINER

AIR-OIL RECEIVING TANK

OIL LEVER

Figure: 5-5 Primary Air Strainer and Receiving Tank

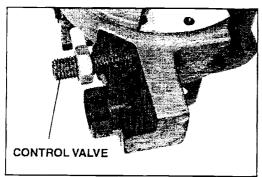


Figure: 5-6 Air Intake Control Valve

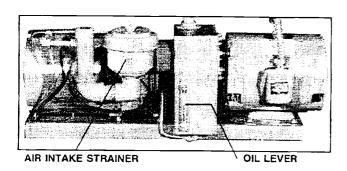


Figure: 5-7 Atomizing Air Compressor

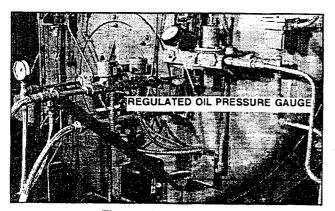


Figure: 5-8 Oil Piping

20 detergent oil of a grade mentioned in Chapter 8 and fill in accordance with instructions given there.

Check the oil level of the air intake strainer. When operating a standard 78" boiler, make certain that the V-belt which drives the air pump is in place and has proper tension.

To verify air flow and pressure, place the burner Run/test Switch on the program relay to the test position. If the burner is a combination fuel burner, be sure that the gas/oil selector switch is set to "oil." Turn the Burner Switch on. The burner will cycle to the low fire pre-purge position and stop there.

Observe the reading on the air pressure gauge (Figure 5-4). With no oil flow, the pressure should be a minimum of 7 psi.

If there is no pressure, determine the cause and correct it before proceeding. Check for obstructions in the air inlet line, incorrect rotation, or a loose oil nozzle or other leaks. If the pressure is much higher without any oil flow, check for obstruction in the discharge line or at the oil nozzle. If there is no obstruction, restrict the air flow by adjusting the air intake valve screw, (see Figure 5-6)

The air pressure will increase when an oil flow exists. At low firing rate, the air pressure may rise to 12 psi or more.

Note: The air pressure should not exceed 35 psi at high fire. Greater air pressure causes excessive wear of the air pump, increases lube oil usage, and can overload the motor, thus causing damage to the equipment.

Note: Abnormally high pressure indicated on the nozzle air pressure gauge is an indication that the burner nozzle has become clogged. In the event of clogging, check the nozzle and clean as necessary.

After air flow has been verified, turn the burner switch off and return the run/test switch to the run position.

# E. FIRING PREPARATIONS FOR NO. 2 OIL (SERIES 100-200)

Prior to initial firing, oil flow and pressure should be established and verified. Atomizing air pressure should also be established as outlined in Section D. The schematic flow diagram (Figure 2-19) indicates the flow of fuel and atomizing air.

If the burner is a combination fuel model, be certain that the Main Gas Shutoff Cock is closed and set the Gas/oil Selector Switch to "oil." Insert the burner drawer gun into its most forward position and latch it in place (see Figure 5-9).

Oil Flow - Open all valves in the oil suction and oil return lines.

If the oil supply tank is located above the level of the pump and flow to the pump is by gravity, then it will usually be

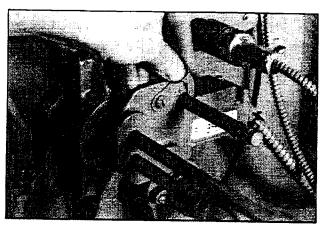


Figure: 5-9 Gun Locked In, Firing Oil

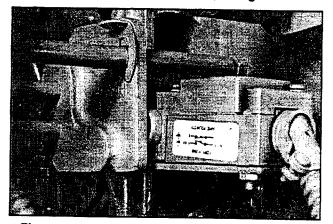


Figure: 5-10 Oil Drawer Switch Closed, Firing Oil

necessary to vent the suction line to allow oil to fill the line. Venting the suction line can generally be accomplished by cracking a union fitting, or by opening the cap of the oil strainer using care to prevent spillage of oil. Tighten the fitting or the cap as soon as oil flow appears.

If the oil supply tank is below the level of the oil pump, it is MANDATORY that the suction line to the pump be completely filled with oil prior to starting the pump to avoid

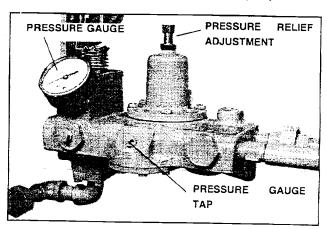


Figure: 5-11 Fuel Oil Controller

the possibility of damage to the pump gears. Non-lubricating fluids such as kerosene should not be used for priming.

Prior to priming the suction line and the initial start, check to make certain that all plugs, connections, etc., have been securely tightened to prevent leaks.

If the fuel oil supply originates from a pressurized loop, it is assumed that the pressure of the loop will be at a minimum of 75 psi. Under these conditions, the relief valve at the terminal block should be adjusted to the point where it becomes inoperative (or removed and openings plugged). To render inoperative, turn the adjusting screw in as far as possible.

A standard equipped boiler has a selector switch incorporated in the oil pump motor starter. Momentarily energize the starter to check for proper pump rotation. With the rotation verified, operate the pump to determine that oil circulation exists. Observe the regulated oil pressure gauge for indication that flow is established. If no pressure shows on the gauge after a few moments, stop the oil pump and re-prime. If the supply tank is lower than the pump, it is possible that the initial priming of the suction line, followed by operation of the pump, will not establish oil flow. This might be caused by obstruction in the suction line, excessive lift, inadequate priming, suction line leaks, etc. If oil flow is not readily established, avoid prolonged operation of the pump to minimize risk of damage to internal parts of the pump. If oil flow is not established after a second or third priming attempt, a full investigation is required to determine the cause.

A vacuum (or a compound pressure-vacuum) gauge should be installed at the suction port of the pump and its reading observed and recorded for future guidance. If a vacuum condition exists, the reading will reveal the tightness of the system. It is advisable to maintain the vacuum reading at less than 10" Hg. A vacuum in excess of 10" Hg. may allow oil to vaporize, causing cavitation, loss of prime, and unstable firing condition.

Oil Pressure - Oil supply pressure is regulated by adjusting the pressure relief valve at the oil terminal block (Figure 2-13). A pressure gauge should be installed in the terminal block and the relief valve adjusted to obtain a minimum reading of 75 psi when the burner is firing at maximum rate.

When oil is supplied from a pressurized loop to a multiple boiler installation, the relief valve in the loop should be properly adjusted to provide this reading. In this circumstance, the relief valve at the terminal block should be adjusted to the point when it will be inoperative (or removed and openings plugged). To render inoperative, turn the adjusting screw in as far as possible.

Adjustment may also be required to the regulator on the fuel oil controller (Figure 2-14, 2-15). The pressure regulating valve is equipped with tubing that directs and adds atomizing air pressure to the adjustable spring pressure. Since the air pump is not running at this time, only tentative adjustment can be made. Without the air supply, adjust the fuel oil

pressure regulator so that the oil burner gauge registers approximately 35 psi.

The pressure gauge will indicate a higher reading when the flame is present and will increase as the firing rate increases. After the burner is firing and when the air pump is running, final adjustment can be made at the fuel oil controller.

Final regulation of oil flow to the nozzle can be done later, if necessary, by adjusting the metering cam screws as outlined in Chapter 6.

**Starting** - When all the conditions covered above and in Sections A, B, C and D are assured, the burner is ready for firing. Refer to Section H of Chapter 5 for further starting and operating information.

### F. FIRING PREPARATION FOR NO. 6 OIL (SERIES 400-600)

Prior to initial firing, oil flow, pressure and temperature should be established and verified. Atomizing air pressure should also be established as outlined in Section D. The schematic flow diagram (Figure 2-19) indicates the flow of fuel and atomizing air. Prior to firing, attach combustion analysis instruments and monitor consistently throughout the startup sequence. Refer to the adjustment procedures in Chapter 6.

If the boiler is a combination fuel model, be certain that the main gas shutoff cock is closed and set the gas/oil selector switch to "oil." Insert the burner drawer gun into its most forward position and latch it in place (see Figure 5-6, 5-7).

Oil Flow - Open all valves in the oil suction and oil return lines. Open the By-pass Valve on the fuel oil controller (Figure 5-9) until oil flow is established. Normally, the Orifice Valve is left in a closed position. However, on cold starts, it may be opened for brief periods to aid in establishing oil flow. The by-pass and orifice valves must be returned to their closed positions as soon as oil flow is established as indicated by a reading on the oil supply pressure gauge (Figures 5-9). Do not attempt to set pressures while valves are open.

Momentarily energize the fuel oil pump starter to check for proper pump rotation. With the rotation verified, prime the suction line strainer with oil and turn the fuel oil pump switch to the "ON" position. Check the oil supply pressure gauge for indication that oil flow is established. If no pressure shows on the gauge after a few moments, stop the oil pump and reprime. Heavy oil in the storage tank must be at a temperature to provide oil viscosity to permit flow through the oil pump and suction line. If oil flow is not established after several attempts, the conditions preventing oil flow must be determined and corrected to avoid damage to the pump's internal mechanism.

A vacuum gauge should be installed in the oil suction line and its reading observed and recorded for future guidance.

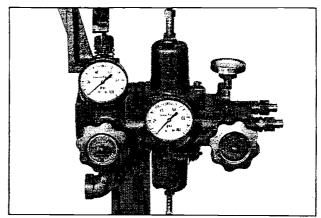


Figure: 5-12 Heavy Oil Fuel Controller

Oil Pressure - Oil pressure is regulated at several points. The first is at the relief valve at the oil heater (Figures 2-17). The relief valve should be set so that at maximum firing rate a minimum reading of 75 psi is obtained on the oil supply pressure gauge.

The other pressure adjustments are to the regulators on the fuel oil controller (Figure 5-8, 5-9). Both the pressure regulating and the back pressure relief valves are equipped with tubing that directs and adds atomizing air pressure to the adjustable spring pressure. Since the air pump is not running at this time, only tentative adjustments can be made. Without the air supply, adjust the fuel oil pressure regulator so that the burner oil gauge registers approximately 35 psi. Adjust the back pressure relief valve so that its gauge reads about 10 psi less than the burner gauge.

After the burner is firing, further adjustments can be made, if necessary, to the valves.

The pressure gauges will indicate higher readings when a flame is present. The pressure will increase as the firing rate increases. The pressure reading on the two gauges on the controller will, despite the fluctuation, retain a nearly constant difference of 10 psi.

Final regulation of oil flow to the nozzle can be done, if necessary, by adjusting the metering cam screws as outlined in Chapter 6.

#### Suggested oil pressures at high fire operation:

Oil Supply at the Fuel Oil Controller	75 psi
Regulated Oil Pressure Gauge	30-45 psi

### **A** CAUTION

Before turning on the electric oil heater switch, be certain that the heater shell is filled with fuel oil and the flow is established. Failure to follow these instructions could result in equipment damage. Oil Temperature - After determining that the heater shell is filled and that fuel oil circulation exists, turn the oil heater switch to "on." Adjust the electric oil heater thermostat (Figures 2-17) to maintain oil temperature at approximately 200°F.

The electric heater on burners equipped for No. 6 fuel oil is sized so that it is capable of supplying heated oil at a rate no greater than that required for low fire operation and is primarily supplied for convenience on cold starts. Heating coils utilizing either steam or hot water are supplied to provide sufficient heat so that higher rates of firing can be accomplished once steam pressure or hot water is available. In normal operation, the thermostat governing the electric heating element is kept at a lower setting than the thermostat governing admission of steam to the heater, or of hot water circulation, so that heating is not performed electrically except when steam or hot water is not available.

Set the steam thermostat (Figure 2-17) or the hot water thermostat (Figure 2-17) to maintain an oil temperature of 220-230°F. The electric heater will be turned off automatically as soon as steam or hot water provides heat.

Note: The temperatures listed are tentative. The composition of the fuel oil in a given grade can vary, necessitating a higher or lower preheating temperature. The viscosity of the oil at the nozzle should be less than 300 SSU and preferably less than 150 SSU. The actual temperature of the oil at the burner should be determined by flame appearance and good combustion based on a stack analysis. See Chapter 5 for additional information.

Close the manual by-pass valve after the temperature rise on the fuel oil controller thermometer is noted. Be certain that hot oil is moving through the controller. The orifice gate valve must also be closed. If the temperature drops, open the orifice gate valve until a rise is noted, then close it.

Once the correct setting of the heater thermostats has been established, set the low oil temperature switch (Figures 2-17)



Figure: 5-13 Oil Gun Locked in OUT Position

at the point approximately 30°F lower than the normal burning temperature. If the system is equipped with a high oil temperature switch, it should be set to open at 20 -30°F higher than normal burning temperature.

# Note: The maximum oil temperature allowed in the system is 250°F.

Starting - When all the conditions covered above and in Sections A, B, C and D are assured, the burner is ready for firing. Refer to Section H of Chapter 5 for further starting and operating information.

# G. FIRING PREPARATIONS FOR GAS (SERIES 200-400-700)

- Prior to initial starting, check the linkage attached to the gas butterfly valve to assure that movement is free from binding.
- Verify the presence and availability of gas. On a new installation, representatives of the gas utility should be present when gas first flows into the system to supervise purging of the new gas line, unless they have already done so.
- Determine that the pilot is operating properly, as outlined in Section C, Chapter 5.
- Determine that sufficient pressure exists at the entrance to the gas train by installing a test gauge downstream of the regulator.
- The gas pressure regulator must be adjusted to the proper pressure level. Since the regulator is generally supplied by others, adjustment should proceed according to instructions supplied by its manufacturer.

It is necessary for the operator to know the burner requirements in gas quantity and pressure. The information can generally be found on the Dimension Diagram (DD) supplied by Cleaver-Brooks for the specific installation. Should the information not be readily available, consult the Cleaver-Brooks Service Department giving the boiler serial number. Chapter 6 contains additional information along with standard gas flow and pressure requirements.

- If the burner is a combination fuel model, set the gas/oil switch to "gas." Withdraw the oil burner gun and latch it in its rearward position (Figure 5-10).
- On initial start-up, it is recommended that the main gas shutoff cock (Figure 2-12) remains closed until the programmer has cycled through prepurge and pilot sequences. When the fuel light on the control panel comes on, observe the action of the motorized gas valve stem to determine that it opens when energized. As soon as it is confirmed, turn the burner switch "OFF" and let programmer finish its cycle. Check that the gas valve has closed. Again, turn the burner "ON". When the fuel valve light glows, slowly open the main gas cock. Main flame should ignite unless there is air present in the line. If the flame is not established within about 5 seconds, turn the burner switch "off" and allow the

programmer to recycle normally for a new lighting trial. Several efforts may be necessary to "bleed" air from the line.

# **WARNING**

Do not repeat unsuccessful lighting attempts without re-checking the burner and pilot adjustments. Failure to follow these instructions could result in serious personal injury or death

Note: The burner and control system is designed to provide a "prepurge" period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system or to take any action that might circumvent the feature.

Once the main flame is established, turn the Burner Switch to the "OFF" position and observe that the flame is extinguished promptly. The flame may continue to burn for a second or two after normal shutdown due to the gas remaining downstream from the fuel valve. If the flame continues to burn for a longer period or during blower motor spindown, it could indicate a main gas valve leak. Immediately turn the Burner Switch off and close the main gas cock. Investigate and correct the cause of the valve leakage before relighting the burner. The main gas valve should provide a tight seal, provided nothing prevents tight closure. Foreign material may be present in either

the new or renovated gas lines unless adequate care is taken in cleaning and purging.

When the conditions covered in Section G and in Sections A, B and C are assured, the burner is ready for firing. Refer to Section H, Chapter 5 for further starting and operating information.

#### H. IFGR SETUP

Note: Initial IFGR linkage settings and adjustments must be established by a Cleaver-Brooks authorized representative. Set up of the LE Option requires simultaneous consideration of air-to-fuel ratios and NOx levels. This can only be accomplished with proper combustion emissions monitoring equipment with NOx, O2, CO, and smoke spot measuring capability.

It is recommended that the final "installed" settings as noted on Figure 5-11, 5-12 and 5-13 be recorded for future reference. The settings should be marked on the linkage as well.

Normally, once the system has been set and adjusted, the settings should not be changed unless conditions (including boiler settings) change. In that case, it will be necessary to contact your local Cleaver-Brooks authorized representative for assistance.

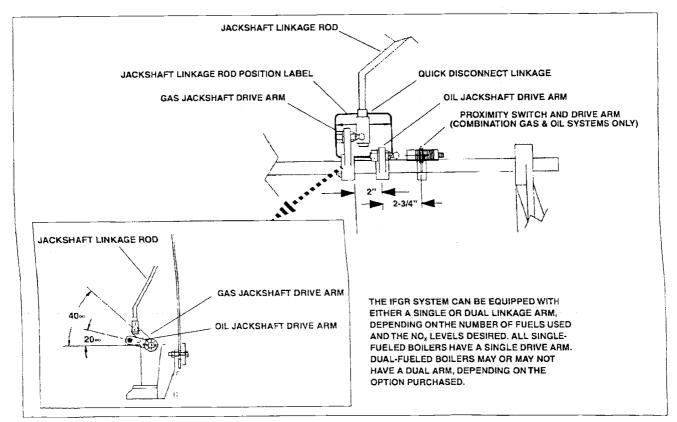


Figure: 5-14 Jackshaft Linkage Settings

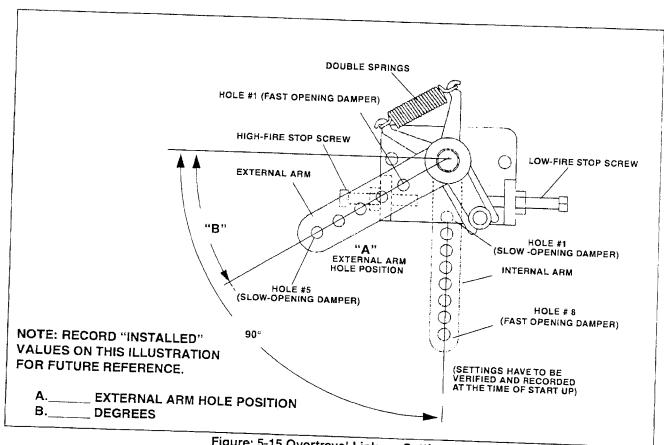


Figure: 5-15 Overtravel Linkage Settings

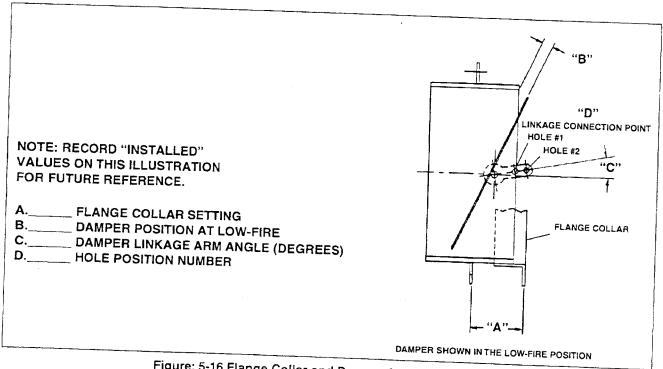


Figure: 5-16 Flange Collar and Damper Settings (Top View)

After the IFGR system is initially set up, it will start up with the boiler as an integrated boiler system. After shut down periods in which maintenance and /or adjustments have been performed on the fuel cams, fuel and air linkages, or IFGR control linkages, the recommended approach to start-up is as follows:

- 1. Set all boiler components to their initial settings as discussed in the appropriate chapters of this Operation and Maintenance manual.
- Check fan impeller and motor rotation. Correct rotation is counter-clockwise when viewed from the front of the boiler.
- 3. Verify that all the IFGR components are set to the settings recorded on the Start Up report or in Figures 5-11, 5-12 and 5-13 (as noted by the Cleaver-Brooks authorized representative during original set up). Be sure that all linkages are secure.
- 4. Start and warm the boiler as described in this Operation and Maintenance manual.
- 5. Adjust the boiler components as described in this Operation and Maintenance manual to achieve proper boiler operation.

Refer to Chapter 8, Figure 8.8 for instructions on cassette removal and installation.

# I. START-UP, OPERATING AND SHUTDOWN - ALL FUELS

Depending upon the fuel being burned, the applicable previous sections in Chapter 5 should be reviewed for preliminary instructions.

When firing with oil, be certain that the **Burner Gun** is in its most forward position and latched in place (see Figure 5-6). When firing with gas, the burner gun should be properly withdrawn and latched in place. The fuel selector switch should be, accordingly, set to either oil or gas.

Set the Manual-Automatic Switch (Figure 2-8) to "manual" and turn the manual flame control to "close."

Turn burner switch to "ON." The load demand light should glow. The low-water level light should remain out, indicating a safe water level in the boiler. The programmer is now sequencing. See Chapter 4 for sequence details.

Note: On an initial starting attempt, several efforts might be required to accomplish "bleeding" of fuel lines, main or pilot. If ignition does not then occur, do not repeat unsuccessful attempts without rechecking the burner and pilot adjustment.

On ignition failure, the flame failure light will glow and the blower will purge the boiler of unburned fuel vapors before stopping. After ignition failure, wait a few moments before re-setting the lockout switch.

# **A** WARNING

Do not re-light the pilot or attempt to start the main burner, either oil or gas, if the combustion chamber is hot and/or if gas or oil vapor combustion gases are present in the furnace or flue passages. Failure to follow these instructions could result in serious personal injury or death

# **A** WARNING

The burner and control system is designed to provide a "pre-purge" period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system or take any action that might circumvent the "pre-purge" feature. Failure to follow these instructions could result in serious personal injury or death

After main flame ignition, the burner should be set on manual control at its low fire setting (that is, with manual flame control at "close") until the boiler is properly warmed. Close the steam header.

In the case of a steam boiler, CLOSE THE TEST VALVE when the steam begins to appear.

A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. The entire water content of the system and boiler must be warmed prior to increasing fuel input.

If the flame at low fire provides insufficient heat to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the Manual Flame Control in one point increments to no higher than the third cam screw. Operate at the increased fuel input rate for a period of time until an increase is noted in pressure or temperature.

After the boiler is thoroughly warmed, turn the manual flame control to high fire. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. Refer to the adjustment procedures in Chapter 6. After making the high-fire adjustment, manually decrease the firing rate, stopping at each cam screw to analyze combustion gases, and adjust as required.

To properly perform the testing and adjusting, it is necessary that the burner be allowed to fire at a maximum rate long enough to achieve desired results.

Operating - Normal operation of the burner should be with the switch in the automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual position at other than low fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. The hot flame to cool air cycling subjects the pressure vessel metal and refractory to undesirables conditions.

With the switch set at "auto," the burner will operate on a modulating basis according to the load demand.

The burner will continue to operate with modulated firing until the operating limit pressure or temperature is reached, unless:

- 1. The burner is manually turned "off."
- 2. A low-water condition is detected by low-water level control.
- 3. The electrical or fuel supply is interrupted.
- The combustion air pressure or atomizing air pressure drops below minimum level.

Note: There can be other reasons for shutdown such as motor overload, flame outages, tripped circuit breakers, blown fuses, or through other interlock devices in the circuitry.

When the burner is shut down normally, by either the **Operating Limit Control** or by manually switching the burner off, the load demand light no longer glows.

Shutdown through conditions causing safety or interlock controls to open will actuate the Flame Failure Light (and alarm if so equipped) and the Load Demand Light will remain lit. The cause of this type of shutdown will have to be located, investigated, and corrected before operation can be resumed. Refer to the "trouble-shooting" section in Chapter 7.

Shutdown - When the Operating Limit Control setting is reached to open the circuit or if the burner switch is turned "off," the following sequence occurs.

The fuel valve is deenergized and the flame is extinguished. The timer begins operation and the blower motor continues running to force air through the furnace in the post-purge period.

At the end of the programmed post-purge period, the blower motor is turned off. The air pump motor of an oil-fired burner is also turned off. The timer has returned to its original starting position and stops. The unit is ready to re-start.

# **A** WARNING

It is advisable to check for tight shut-off of fuel valves. Despite precautions and strainers, foreign material in either new or renovated fuel lines may lodge under a valve seat and prevent tight closure. The situation is especially true in new installations. Promptly correct any conditions causing leakage. Failure to follow these instructions could result in serious personal injury or death

### J. CONTROL OPERATIONAL TEST AND CHECKS

Proper operation of the various controls should be verified and tested when the boiler is initially placed into service, or whenever a control is replaced. Periodic checks should be made thereafter in accordance with a planned maintenance program.

The operating limit control may be checked by allowing steam pressure or water temperature to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner shut off point. If the load is heavy, the header valve can be closed or throttled until the pressure increases. Observe the steam gauge to check the cut off pressure as the operating limit control shuts the burner down. Slowly open the header valve to release steam pressure and check the cut-in setting as the burner restarts. Check the modulating control for the desired operating pressure range. See Chapter 6 for instructions on the adjustment of controls.

The water temperature on a hot water boiler that may be operating at less than full load may be raised by manually increasing the firing rate until the burner shuts down through the action of the operating limit control. Observe the thermometer to verify the desired settings at the point of cutout and again when the burner restarts. Return the manual automatic switch to "automatic" and check the modulating control for the desired temperature range. See Chapter 6 for instructions on the adjustment of the controls.

Check the proper operation and setting of the low-water cutoff (and pump operating control, if used).

Proper operation of the flame failure device should be checked at startup and at least once a week thereafter. Refer to Chapter 8 for information on flame safety checks. Check the program relay's annunciation for any system failure. Observe the promptness of ignition of the pilot flame and the main flame.

Check for tight shut-off of all fuel valves. Despite precautions and strainers, foreign material may lodge under a valve seat and prevent tight closure. Promptly correct any conditions that cause leakage.

# **CHAPTER 6**

# **Adjustment Procedures**

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Note: If your boiler is equipped with a CB-HAWK™ boiler management control system, refer to CB-HAWK Installation, Operating and Servicing Manual No. 750-133 for specific information regarding procedures described in this section.

#### A. GENERAL

Each Cleaver-Brooks boiler is tested for correct operation before shipment from the factory. However, variable conditions such as burning characteristics of the fuel and operating load conditions will require further adjustment. Contact your local qualified Cleaver-Brooks Service representative after installation to assure correct start-up and maximum operating efficiency and economy.

A combustion efficiency analysis made during the initial start-up will help to determine what additional adjustments are required in a particular installation.

Prior to placing the boiler into service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts and setscrews to be sure that no damage has occurred, or that adjustments have not changed during shipment and installation.

The adjustment procedures in Chapter 6 apply to standard components furnished on steam or hot water boilers fired with gas and/or the various grades of oil.

## HIGH TURNDOWN BURNER

In order to reduce stress on boiler components and to improve boiler operating efficiency, burners have been designed for enhanced fuel turndown capabilities. A High Turndown Burner (HTB) is installed on boilers equipped to fire light oil (Series 100), or gas (Series 700), or both (Series 200). Air and fuel inlets, the diffuser, and the air damper control linkage have been modified for these burners.

Note: Observe that proper air damper linkage and fuel metering adjustment procedures are followed for standard (Series 400 or 600) or HTB (Series 100, 200, or 700) burners to avoid damage to the equipment. The burner series is identified on the boiler data plate affixed to the front head of the boiler

Contact your local Cleaver-Brooks authorized representative or the Cleaver-Brooks Service Department for recommendations covering special controls that are not included in Chapter 6.

# B. LINKAGE - MODULATING MOTOR AND AIR DAMPER

The linkage consists of various arms, connecting rods, and swivel ball joints that transmit motion from the modulating motor to the metering cam(s), to the rotary air damper, and to the gas butterfly valve, if used.

When properly adjusted, a coordinated movement of the damper and metering cams within the limits of the modulating motor travel is attained to provide proper fuel-air ratios through the firing range

In linkage adjustments there are several important factors that must serve as guides. 1. The modulating motor must be able to complete its full travel range.

### **A** CAUTION

Do not restrict the full travel of the modulating motor. Failure to follow these instructions could result in equipment damage.

2. Initial adjustment should be made with the motor in full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.

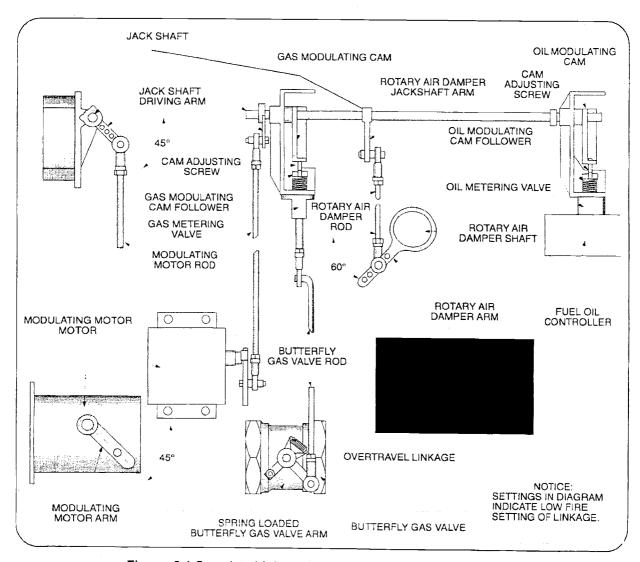


Figure: 6-1 Complete Linkage Assembly - Combination Gas and Oil

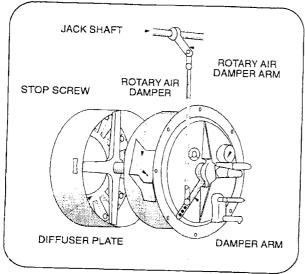


Figure: 6-2 Rotary Air Damper

- 3. The closer the connector is to the drive shaft, the less the arm will travel; the closer the connector is to the driven shaft, the farther that arm will travel.
- Over-travel linkage, where used, should not be required in order to extend its spring to the fullest stretch.

With the modulating motor in the low fire position, the arm on its shaft should be at an angle of 45° below the horizontal. The driven arm on the jack shaft should also be 45° below horizontal. Secure both arms and fit the connecting linkage rod in place between them. Refer to Figure 6-1.

Position the oil and/or gas modulating cams on the jackshaft so that the cam follower assembly is between the first and second cam adjusting screws (under the first adjusting screw for High Turndown Burners). In this position, fuel delivery is at low fire rate. Tighten the set screws to secure the cams on the jackshaft.

Refer to Figure 6-2. The stop screw in the rotary air damper limits damper travel at both closed (low fire) and fully opened (high fire) positions. The screw is provided so that it is possible to tell, even with the burner in place, whether the damper rotor is in fully opened or closed position. Rotating the damper clockwise to the stop screw opens the damper. Rotating the damper counterclockwise to the stop screw closes the damper. Normally, the rate of flow of air through the damper with the rotor in low fire position is about one-third of maximum for a standard burner or one-sixth for a HTB.

The amount of angular movement controlling the rate of air flow is determined by the location of the ends of the rotary air damper rod in both the jack shaft arm and the air damper arm. When the air damper is in low fire position, the jackshaft arm should be at 45° (47-1/2° for HTB) and the rotary air damper arm should be at an angle of approximately 60° below the horizontal (Figure 6-1). This will ensure that the angular

movement of the damper starts slowly, increasing in rate as the high fire position is approached.

Prior to initially firing a boiler it is advisable to check for free movement of the linkage. The damper motor must be allowed to complete its full stroke and the damper must move freely from low to high fire position. Adjustment of linkage connected to a gas butterfly valve is described in Section Q of Chapter 6.

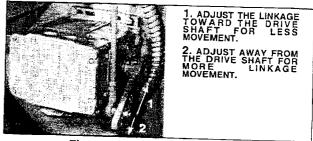


Figure: 6-3 Modulating Motor

# C. MODULATING MOTOR

The modulating motor has a 90° shaft rotation. The motor manufacturer also provides a 160° stroke model for other applications. If a replacement is obtained from someone other than a Cleaver-Brooks Service or Parts representative, it may have an incorrect stroke. To prevent damage, determine the 90° stroke prior to installing a replacement.

The stroke may be determined by powering the motor and connecting terminals R-B to actually determine the stroke as motor drives to an open position.

# D. MODULATING MOTOR SWITCHES - LOW FIRE AND HIGH FIRE

The modulating motor contains either one or two internal switches depending upon application. The microswitches are actuated by adjustable cams attached to the motor shaft.

Note: If the boiler is equipped with the CB-Hawk, there are no end switched. Do not attempt to adjust the Modulating Motor if the unit is equipped with the CB-Hawk

Factory replacement motors have the cams preset. The low fire start switch is set to make the red and yellow leads at approximately 8° on motor closing. The high fire purge air proving switch (located in the modulating motor) is set to make red and blue tracer leads at approximately 60° the on motor opening. Normally the settings are left as is, but job conditions may require readjustment. If the cams require adjustment or resetting, follow the instructions in the manufacturer's technical manual.

# E. BURNER OPERATING CONTROLS - GENERAL

Note: Adjustments to the boiler operating controls should be made by an authorized Cleaver-Brooks Representative. Refer to the appropriate boiler Operation and Maintenance manual for specific information on boiler startup and operation.

The standard boiler operating control package consists of three separate controls, the <u>High Limit Control</u>, <u>Operating Limit Control</u> and the <u>Modulating control</u>.

The <u>High Limit Control</u> senses the hot water temperature or steam pressure. It is used as a safety limit to turn the burner off in the event the operating limit control fails. The high limit control should be set sufficiently above the operating limit control to avoid nuisance shutdowns.

The **Operating Limit Control** senses temperature or pressure and automatically turns the burner on to initiate the start up sequence when required and turns the burner off to initiate the shutdown sequence when the demand is satisfied. The control must be set to initiate startup only at the low fire position.

The <u>Modulating Control</u> senses changes in the hot water temperature or steam pressure and signals the modulating motor to control the flow of fuel and air to the burner. With either steam or hot water boilers, the modulating control must be set to ensure the burner is at its minimum low fire position before the operating limit control either starts or stops the burner.

When adjusting or setting controls, first be sure all control devices are securely mounted and level. With the temperature sensing control, make sure the sensing bulb is properly bottomed in its well and is secured against movement. Be sure the connecting tubing is not kinked.

The dial settings are generally accurate, although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading. Always adjust control setting to agree with pressure gauge or thermometer readings. Accurate instrument readings are required. When necessary use auxiliary test equipment to set controls.

Burner controls correctly set to match load demands will provide operational advantages and achieve the following desirable objectives:

- The burner will be operating in low fire position prior to shut down.
- The burner will operate at low fire for a brief period on each start during normal operation.
- · Eliminates frequent burner on-off cycling.

Separate and independent controls affect modulated firing and burner on-off cycling. Figure 6-6 depicts a typical setting relationship of the <u>Operating Limit Control</u>, <u>Modulating</u> Control and the High Limit Control.

The burner will be "on" whenever the pressure or temperature is less than point **B** and "off" whenever pressure or temperature is greater than point **A**. The distance between points **A** and **B** represents the "on-off" differential of the **Operating Limit Control**.

In normal operation, the burner will shut down whenever the pressure or temperature rises above setting A. At that point the switch in the <u>Operating Limit Control</u> will open. As the pressure or temperature drops back to B, the <u>Operating Limit Control</u> closes and the burner will restart. The <u>Modulating Control</u> will signal the modulating motor to be in a low fire position. If the load demands exceed the low fire input potential, the <u>Modulating Control</u> will increase the firing rate proportionately as pressure or temperature falls toward point D. The modulating motor will stop at any

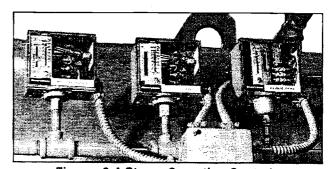


Figure: 6-4 Steam Operating Controls

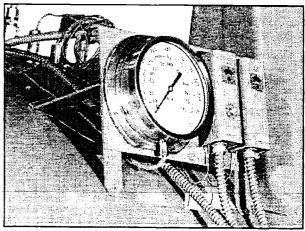


Figure: 6-5 Hot Water Controls

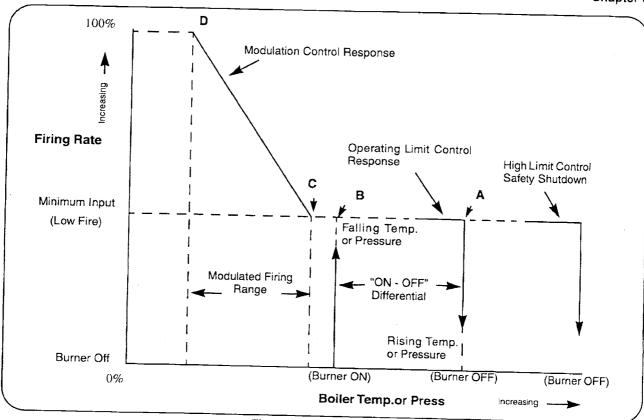


Figure: 6-6 Firing Graph

intermediate point between C and D whenever the fuel input balances the load requirement.

As the load requirement changes, the firing rate will change accordingly. Thus it is referred to as modulated firing.

Point **D** represents the maximum firing rate of the burner, or highfire. In the event pressure or temperature drops while the burner is firing at highfire, it indicates that the load exceeds the capacity of the boiler.

The firing graph (Figure 6-6) shows that point **B** and point **C** do not coincide. Extreme load conditions could require the points be closely matched.

When set as shown, with a time lag between **B** and **C**, the burner will be in a low fire position upon a restart and will fire at that rate for a short period of time before falling pressure or temperature requires an increase in the firing rate.

Note: On-Off cycling in excess of 8 cycles per hour will shorten the life of the combustion air motor and cause excessive wear on switch gear and pilot electrodes.

If points B and C overlap when restart occurs, the burner would drive to a higher firing position immediately after the main flame was proven.

Note: It is not recommended that the boiler controls be set so as to overlap the modulating control range and operating control range.

When firing a cold boiler, it is recommended that the burner be kept at low fire, under manual flame control, until normal operating pressure or temperature is reached. If the burner is not under manual control on a cold start, it will immediately move toward high fire as soon as the program control releases the circuit that holds the burner in low fire. The modulating control will be calling for high fire and the burner will move to that position as rapidly as the damper motor can complete its travel.

Note: Rapid heat input can subject the pressure vessel metal and refractory to undesirable conditions.

Do not operate the boiler at a temperature in excess of 90% of the safety valve relief setting. The closer the operating pressure is to the safety valve relief pressure, the greater the possibility of valve leakage. Continued leakage, however slight, will cause erosion and necessitate early safety valve replacement. The control settings on a hot water boiler must be within the temperature limits of the boiler.

Ideally, the boiler operating controls should be set under actual load conditions. Especially under new construction conditions, the boiler is initially started and set to operate under less than full load requirements. As soon as possible thereafter, the controls should be reset to provide maximum utilization of the modulating firing system. To accomplish maximum utilization, and assuming that air/fuel combustion

ratios have been set, make the required adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

To properly set the <u>Modulating Control</u>, carefully adjust it under load conditions, until the load is maintained with the burner firing at a steady rate. The firing rate at that point may be full high fire or slightly less, depending upon the relationship of the boiler size to the load.

When the <u>Modulating Control</u> is set and the burner is in full high fire, the scale setting of the <u>Modulating Pressure Control</u> on a steam boiler will indicate the low point of the modulating range. The scale setting of the <u>Modulating Temperature Control</u> on a hot water boiler will have a reading that indicates the midpoint of the modulating range.

The <u>Operating Limit</u> control should now be adjusted and the differential established. In an installation that does not require a very close control of steam pressure or water temperature the adjustable differential (Figure 6-6 A to B) should be set as wide as conditions permit, since a wide setting will provide less frequent burner cycling.

The <u>High Limit Control</u> provides a safety factor to shut the burner off in the event the <u>Operating Limit Control</u> should fail. The setting of the control should be sufficiently above the <u>Operating Limit Control</u> to avoid nuisance shutdowns. The setting, must be within the limits of the safety valve settings and should not exceed 90% of the valve setting. The control requires manual resetting after it shuts off the burner.

In the setting of the controls, consideration must be given to the time required for a burner restart. Each start, requires a prepurge period, plus the fixed time required for proving the pilot and main flame. In addition, approximately one-half minute is required for the damper motor to travel from low to high fire. The time lag may allow pressure or temperature to drop below desirable limits.

# F. MODULATING PRESSURE CONTROL (Steam)

Turn the adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between the low point and a higher point equal to the modulating range of the particular control. In 0-15 psi controls the range is 1/2 lb; in 5-150 psi controls the range is 5 lbs; in 10-300 psi controls the range is 12 lbs.

### **A** CAUTION

To prevent burner shutdown at other than low-fire setting, adjust the modulating pressure control to modulate to low fire BEFORE the operating limit pressure control shuts off the burner. Failure to follow these instructions could result in damage to the equipment.

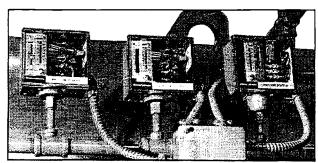


Figure: 6-7 Steam Operating Controls

# G. OPERATING LIMIT PRESSURE CONTROL (Steam)

Set the "cut-out" (burner-off) pressure on the main scale using the large adjusting screw. Set the differential on the short scale by turning the small adjusting screw until the indicator points to the desired difference between cut-out and cut-in pressures. The "cut-in" (burner-on) pressure is the cut-out pressure MINUS the differential. The cut-out pressure should not exceed 90% of the safety valve setting.

# H. HIGH LIMIT PRESSURE CONTROL (Steam)

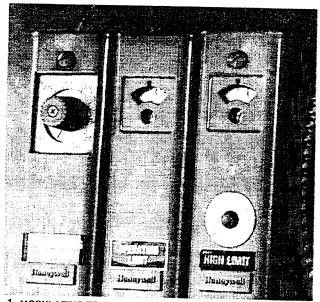
Set "cut-out" (burner off) pressure on the main scale using the adjusting screw. The control will break a circuit when pressure reaches this point. The setting should be sufficiently above the operating limit pressure control to avoid shutdowns, and preferably not exceed 90% of safety valve setting. The control requires manual resetting after tripping on a pressure increase. To reset, allow pressure to return to normal and then press the reset button.

# I. MODULATING TEMPERATURE CONTROL (Hot Water)

Turn the knob on the front of the case until the pointer indicates the desired setpoint temperature. The desired set point is the center point of a proportional range. The control has a 3 to 30° differential and may be adjusted to vary the temperature range within which modulating action is desired. With the cover off, turn the adjustment wheel until pointer indicates desired range.

## **A** CAUTION

To prevent burner shutdown at other than low-fire setting adjust modulating temperature control to modulate low fire BEFORE operating limit temperature control shuts off burner. Failure to follow these instructions could result in damage to the equipment.



- 1. MODULATING TEMPERATURE CONTROL
- 2. OPERATING TEMPERATURE CONTROL
- 3. HIGH LIMIT TEMPERATURE CONTROL

Figure: 6-8 Hot Water Controls

# J. OPERATING LIMITTEMPERATURE CONTROL (Hot Water)

Set "cut-out" (burner off) temperature on the scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw. The "cut-in" (burner on) temperature is the cut-out temperature MINUS the differential. The differential is adjusted from 5 to 30° F.

# K. HIGH LIMIT TEMPERATURE CONTROL (Hot Water)

Set the "cut-out" (burner off) temperature on scale using the adjusting screw. The control will break the circuit and lock out on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. On a 30 psig hot water boiler, the setting is not to exceed 240° F. The control requires manual resetting after tripping on a temperature increase. To reset, allow the water temperature to drop below the cut-out setting less differential, and then press the manual reset button.

# L. LOW WATER CUTOFF DEVICES (Steam and Hot Water)

No adjustment is required since LWCO controls are preset by the original manufacturer. However, if the water level is not maintained as shown in Figure 3-2, inspect the devices immediately and replace as required.

# M. COMBUSTION AIR PROVING SWITCH (CAPS)

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of combustion air. The pressure of the combustion air is at its minimum value when the damper is full open. The Combustion Air Proving Switch should be adjusted with the damper fully open. It should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The run/test switch on the program relay should be set to TEST. Turn the burner switch on. The blower will start (provided that all limit circuits are completed) and the programmer will remain in the low-fire (damper closed) portion of the prepurge.

Note: On an oil fired boiler, the atomizing air proving switch (AAPS) must also be closed.

Note: On a combination fuel fired burner, the fuel selector switch could be set at "gas" to eliminate the atomizing air proving switch from the circuitry.

To have the modulating damper motor drive to high fire (damper open), remove the cover from the motor and remove the wire from terminal W.

Slowly turn down the <u>Combustion Air Proving Switch</u>, adjusting, screw until it breaks the circuit. Here the programmer will lock out and must be manually reset before it can be restarted. Add a half turn or so to the adjusting screw to remake its circuit.

Recycle the program relay to be sure that normal operation is obtained. Replace the wire on terminal W and reinstall the cover. Return the test switch to the RUN position.

## N. ATOMIZING AIR PROVING SWITCH

The air pressure against the diaphragm actuates the switch which, when closed, completes a circuit to prove the presence of atomizing air. The pressure of the atomizing air is at its minimum value when there is no fuel present at the nozzle. Adjustment of the switch should be done while the unit is running but not firing. The control should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The control adjustment may be made during the prepurge period of operation by stopping the programmer during the prepurge period through the use of the TEST switch. Refer to the control instruction bulletin for details. The adjustment screw of the <u>Atomizing Air Proving Switch</u> can then be adjusted until it breaks the circuit. Here, the programmer will lock out and must be manually reset before it can be restarted. Turn the adjusting screw up a half turn or so to remake the circuit.

The adjustment of the air switch may be made either during the damper closed or damper open position of prepurge. It is also possible to make the adjustment with the relay stopped in the damper open position in a similar manner to the adjustment of the **Combustion Air Proving Switch** described in Section M.

After making the adjustment, recycle the control to be sure that normal operation is obtained. The TEST switch must be set to RUN position.

#### O. GAS PILOT FLAME ADJUSTMENT

The size of the gas pilot flame is regulated by adjusting the gas flow through the <u>Pilot Gas Regulator</u> and the <u>Pilot Adjusting Cock</u> on the front of the burner. The flame must be sufficient to ignite the main flame and to be seen by the flame detector. But an extremely large flame is not required. An overly rich flame can cause sooting or carbon buildup on the flame detector. Too small a flame can cause ignition problems.

Although it is possible to visibly adjust the size of the pilot flame, it is preferable to obtain a microamp or voltage reading of the flame signal.

The correct voltage or microamp readings can be found in the information supplied with the flame safeguard system.

The program relay used may be of the type that provides message information that includes a constant flame signal of de voltage. In this case a separate de voltmeter is not required.

#### To Measure and Adjust Pilot:

When making a pilot adjustment, turn the <u>Manual-Automatic Switch</u> to "manual" and the <u>Manual Flame Control</u> to "close," Open both the <u>Pilot Cutoff Cock</u> and the <u>Pilot Adjusting Cock</u>. The <u>Main Gas Cock</u> should remain closed.

The regulator in the pilot line, if provided, is to reduce the gas pressure to suit the pilot's requirement of between 5 to 10" WC. Regulator adjustment is not critical; however, with a lower pressure the final adjustment of the pilot flame with adjusting cock is less sensitive.

- 2. Connect the micro-ammeter as outlined earlier.
- Turn the burner switch on. Let the burner go through the normal prepurge cycle. When the ignition trial period is signaled, set the test switch to the TEST position to stop the sequence.
- 4. If the pilot flame is not established within 10 seconds, turn off the burner switch. Repeat the lighting attempt.

Note: On an initial starting attempt, portions of the fuel lines may be empty and require "bleeding" time. It is better to accomplish this with repeated short lighting trial periods with intervening purge periods than to risk prolonged fuel introduction. If the pilot does not light after several attempts, check all components of the pilot system.

5. When the pilot flame is established, and with the <u>Pilot Adjusting Cock</u> wide open, remove the <u>Flame Detector</u> from the burner plate. The pilot flame can then be observed through this opening.

## **A** WARNING

Wear a protective shield or suitable glasses and keep eyes sufficiently away from the sight tube opening to avoid serious personal injury or death. Never remove the flame detector while the main burner is firing. Failure to follow these instructions could result in serious personal injury or death.

## **AWARNING**

When checking the pilot flame, be aware the electrode is energized. Failure to follow these instructions could result in serious personal injury.

6. To make the final adjustment, slowly close the <u>Gas Pilot Adjusting Cock</u> until the flame can no longer be seen through the sight tube. Then slowly open the cock until a flame providing full sight tube coverage is observed.

The adjustment must be accomplished within the time limit of the safety switch or approximately 30 seconds after the detector is removed. If the control shuts down, manually reset it. Replace the detector and repeat the process from step 5.

7. When a suitable flame as indicated in paragraph 6 is obtained, replace the detector. Observe the reading on the micro-ammeter. The reading should be between 2-1/4 and 5 microamps when using a lead sulfide detector and a standard amplifier. See the flame signal table in the manufacturer's bulletin for values of other combinations.

The flame signal indicated on the annunciator type relay should not be less than 10 Vdc, and may be as high as 20 Vdc or greater.

The reading must be steady. If the reading fluctuates, recheck the adjustment. Be sure that the flame detector is properly seated and that the lens is clean.

8. Return the test switch to the RUN position.

- If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.
- 10. The reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in paragraph 7. If there are any deviations, refer to the trouble shooting section in the technical bulletin.

# P. GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields highest combustion efficiency at rated performance yet prevents overfiring. Once the optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency. Since the gas pressure regulator itself is usually furnished by others, detailed adjustment instructions and adjusting procedures recommended by the manufacturer should be followed.

#### Pressure

The gas supplied must provide not only the quantity of gas demanded by the unit, but must also be at a pressure high enough to overcome the pressure-loss due to the frictional resistance imposed by the burner system and the control valves.

The pressure required at the entrance to the burner gas train (Figure 2-13) for rated boiler output is termed "net regulated pressure." The gas pressure regulator must be adjusted to achieve the pressure to assure full input.

The pressure requirement varies with boiler size, altitude, and type of gas train. Refer to Table 6-2 for pressure requirements.

The pressures listed are based on 1000 Btu/cu-ft natural gas at elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from Table 6-2.

#### Gas Flow

The volume of gas flow is measured in terms of cubic feet and is determined by a meter reading. The gas flow rate required for maximum boiler output depends on the heating value (Btu/cu-ft) of the gas supplied and boiler efficiency. The supplying utility can provide the information.

Pressure Required at Gas Train Entrance with Two Valves and 3" Pipe			
BOILER HP	Standard	нтв	LE
250	17.5" W.C.	22.0" W.C.	23.0" W.C.
300	23.0" W.C.	31.0" W.C.	32.5" W.C.
350	32.5" W.C.	42.5" W.C.	45.0" W.C.

Table 6-1. Minimum Net Regulated Gas Pressure for Rated Boiler Output

ALTITUDE FEET ABOVE SEA LEVEL	CORRECTION FACTOR
1000	1.04
2000	1.07
2500	1.09
3000	1.11
4000	1.16
5000	1.21
6000	1.25
7000	1.30
8000	1.35
9000	1.40

Table 6-2. Pressure/Altitude Correction Factors

BOILER HP	HIGH FIRE INPUT Btu/hr, (GAS)	LOW FIRE INPUT Btu/hr, (GAS)
250 CB & CB-LE	10,461,000	1,461,000
300 CB & CB-LE	12,553,000	1,255,300
350 CB & CB-LE	14,645,000	1,464,500
BOILER HP	HIGH FIRE INPUT Btu/hr, (OIL)	LOW FIRE INPUT Btu/hr, (OIL)
250 CB & CB-LE	10,461,000	1,307,625
300 CB & CB-LE	12,553,000	1,569,125

Table 6-3. Standard Burner Required Input

BOILER HP	HIGH FIRE INPUT Btu/hr	LOW FIRE INPUT Btu/hr
250 gas	10,460,000	1,046,000
300 gas	12,555,000	1,255,500
350 gas	14,645,000	1,464,500
250 oil	10,460,000	1,307,500
300 oil	12,555,000	1,569,400
350 oil	14,645,000	1,830,600

Table 6-4. High Turndown Burner Required Input

	,
REGULATOR INLET PRESSURE (PSIG)	PRESSURE FACTOR
1	1.05
2	1.11
3	1.18
4	1.25
5	1.32
6	1.39
7	1.45
8	1.53
9	1.59
10	1.66
11	1.72
12	1.81
13	1.86
14	1.93
15	2.00

Table 6-5. Pressure Correction Factors

 $INPUT = \frac{OUTPUT \times 100\%}{EFFICIENCY}$ 

GAS FLOW =  $\frac{INPUT}{GAS BTU's/Ft^3}$ 

= <u>OUTPUT x 100</u> EFFICIENCY x GAS BTU's/Ft<sup>3</sup>

#### **Pressure Correction**

The flow rate outlined in Section P is based on a "base" pressure, which is usually atmospheric or 14.7 psia.

Meters generally measure gas in cubic feet at "line" or supply pressure. The pressure at which each cubic foot is measured and the correction factor for the pressure must be known in order to convert the quantity indicated by the meter into the quantity which would be measured at "base" pressure.

To express the volume obtained from an actual meter reading into cubic feet at base pressure, it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 6-5

#### Conversely:

To determine what the meter index reading should be in order to provide the volume of gas required for input, divide the desired flow rate by the proper pressure correction factor. This answer indicates the number of cubic feet at line pressure which must pass through the meter to deliver the equivalent number of cubic feet at base pressure.

#### As an example:

Assume that a 600 horsepower boiler is installed at 2,000 feet above sea level; is equipped with a standard gas train and a high turndown burner; and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

#### Pressure

Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 37.5" WC gas pressure at sea level (Table 6-1). Table 6-2 indicates a correction factor of 1.07 for 2,000 feet. Multiplying the results in a calculated net regulated gas requirement of approximately 40.1" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

#### Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input (Table 6-3) and "correct" this answer by applying the correction factor for 3 psig (Table 6-5).

<u>Btu/hr Input</u> = CFH (Cubic feet/hour) Btu/cu-ft

OR

<u>25,100,000</u> = 25,100 CFH (At 14.7 Ib-atmospheric base pressure)

THEN

 $\frac{25.100}{1.18}$  = 21,271 CFH

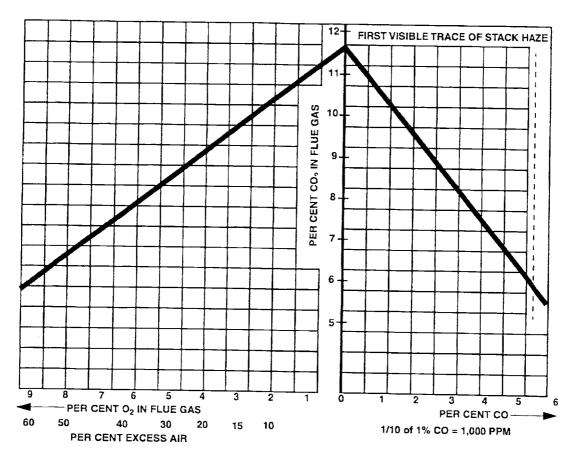


Figure: 6-9 Flue Gas Analysis Chart for Natural Gas

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 25,100 CFH (at base pressure) will be delivered.

#### Checking Gas Flow

Your gas supplier can generally furnish a gas meter flow chart from which gas flow can be determined. After a short observation period, the information aids in adjusting the regulator to increase or decrease flow as required to obtain the rating.

Final adjustment of the gas fuel is carried out by means of the adjusting screws in the gas modulating cam, while performing a combustion efficiency analysis. See Section Q for details.

Note: The information given in this section is for all practical purposes sufficient to set and adjust controls for gas input. Your gas supplier can, if necessary, furnish exact correction factors that take into consideration Btu content, exact base pressure, specific gravity, temperature, etc., of the gas used.

# Q. GAS FUEL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

Note: All adjustment should be done by a qualified boiler operator or your local Cleaver-Brooks Service representative.

Burner efficiency is measured by the amount or percentage of  $\rm O_2$  present in the flue gas.  $\rm O_2$  readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion is a term used to describe a condition when there is the exact amount, molecule for molecule, of air for the fuel attempting to be burned. This can be accomplished under laboratory conditions, however it's not practical to attempt to meet this condition in a boiler. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room temperature and

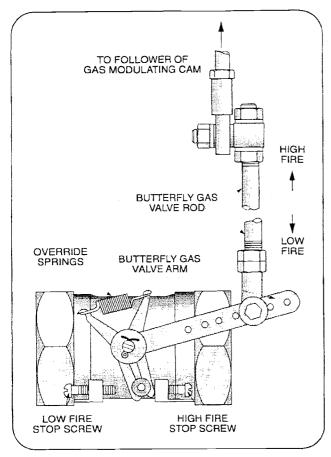


Figure: 6-10 Butterfly Gas Valve

atmospheric conditions, and to ensure the combustion is on the proper side of the combustion curve (See Figure 6-9).

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion or flue gas analyzer. The appearance or color of the gas flame is not an indication of its efficiency, because an efficient gas flame will vary from transparent blue to translucent yellow.

Most flue gas analyzers in use today measure the content, by percentage of oxygen  $(O_2)$  and carbon monoxide (CO) either by percent or parts per million (ppm). Carbon dioxide  $(CO_2)$  is not normally measured with todays flue gas analyzers, but may be displayed via a calculation.

The O<sub>2</sub> levels through the entire firing range of the burner, low fire to high fire should be tested. The burner manufactures recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

## **A** CAUTION

Turndown in excess of the burner design may damage the burner diffuser and/or the burner housing. Failure to follow these instructions could result in damage to the equipment. It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding Figure 6-9 shows the relationship between O<sub>2</sub> levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

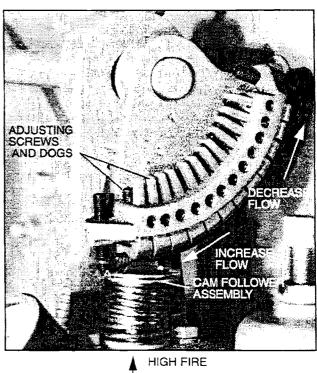
One of the products of combustion is  $CO_2$  (Carbon Dioxide). This is shown in percentage.

Another product of combustion is CO (carbon monoxide) and is shown in both percentage and parts per million (ppm). The maximum CO level standardly allowed is less than 400 ppm. However, this may change subject to local regulations.

The percent  $O_2$  recorded on an instrument equates to percent excess air, i.e. 3%  $O_2$  is approximately 15% excess air and 4%  $O_2$  is approximately 20% excess air. The exact percentage of excess air is a mathematical calculation based on an ultimate fuel analysis of the fuel being fired.

It is generally recommended that  $O_2$  readings of between 3% to 4% be attained with less than 400 ppm CO, at high fire.

Using information from Section P of Chapter 6, determine the standard conditions of gas pressure and flow for the size boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.



LOW FIRE

Figure: 6-11 Fuel Modulating Cam

6-12

Basically, gas adjustments are made with a gas pressure regulator, which controls the pressure and with the butterfly gas valve (Figure 6-10) which directly controls the rate of flow.

In initially setting the linkage, back off the low fire stop screw on the butterfly valve so that the valve is closed. Then run the screw out to touch the arm, and give it two complete turns. Adjust the connecting rod so that the override tension is released and so that the arm is now just touching the stop screw. Tighten the locknuts on all ball joints. See Figure 6-10.

The low fire setting should be regarded as tentative until the proper gas pressure for high fire operation is established.

To reach the high fire rate, turn the manual flame control switch toward "OPEN" in minor increments while monitoring combustion for overly rich or lean conditions.

Set and lock the high fire stop screw so that it is just touching the valve arm.

Determine the actual gas flow from a meter reading. (See section P of Chapter 6.) With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following the manufacturer's directions for regulator adjustment.

When proper gas flow is obtained, take a flue gas reading. The  $O_2$  should be between 3% and 4% at high fire.

If the fuel input is correct, but the  $\rm O_2$  values do not fall within this range, the air damper travel may need to be adjusted. Adjustment of the air damper linkage is described in Section B of Chapter 6.

With the high-fire air/fuel ratio established, the gas pressure regulator needs no further adjusting.

After being certain that the air control damper and its linkage are correctly adjusted to provide the proper amount of combustion air, and after adjusting the gas pressure regulator, final adjustment can be made, if necessary, to the gas modulating cam to obtain a constant air/fuel ratio throughout the entire firing range.

# Note: Be sure the to loosen the cam foot locking screws before adjusting any cam screws or the cam feet may be damaged.

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. The adjustment is made to the metering cam by means of adjusting screws, which are turned outward (counterclockwise from the hex-socket end) to increase the flow of fuel, and inward (clockwise from the hex-socket end) to decrease it. Flow rate is highest when the cam follower assembly is closest to jackshaft. See Figure 6-11.

Through the manual flame control switch, position the cam so that the adjusting screw adjacent to the end or high fire screw

contacts the cam follower. Perform a combustion analysis at this point. If an adjustment is necessary, turn the adjustment screw accordingly to increase or decrease fuel flow. Take a combustion reading to verify input. Repeat as necessary until the desired flow is obtained. Repeat the process, stopping at each adjusting screw, until the low fire adjusting screw is reached.

Note: Do not use any lubricant on the adjusting setscrews. The set screws have a nylon locking insert intended to provide locking torque and resistance to loosening and a lubricant could damage equipment.

## Standard Burner Low Fire Adjustment

The fuel input should be adjusted using the low fire cam screw, to approximately 25% of that at high fire (Table 6-3). At low fire the  $O_2$  flue gas reading should be between 6-7%.

It may be necessary to readjust the setting of the low fire stop screw to obtain the proper air/fuel ratio at the low fire rate. To ensure that the low fire position of the gas butterfly valve is always the same, allow one turn of the stop screw for overtravel.

If the air damper needs to be adjusted in order to provide the correct low fire air/fuel ratio, combustion must be rechecked at higher firing rates and adjusted as required.

If all cam screws are properly adjusted, none will deviate from the general overall contour of the cam face.

# High Turndown Burner Low Fire Adjustment

The fuel input should be adjusted using the low fire cam serew, to approximately 10% of that at high fire (Table 6-4). At low fire the  $O_2$  flue gas reading should be between 9.5-11%. When adjusting a high turndown burner equipped with IFGR, the  $O_2$  readings should be 6 to 7%.

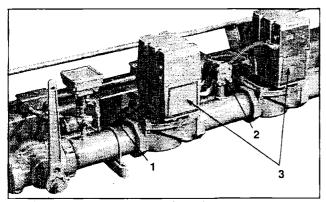
It may be necessary to readjust the setting of the low fire stop screw in order to obtain the proper air/fuel ratio at low fire. To ensure that the low fire position of the gas butterfly valve is always the same, allow a half turn of the stop screw for overtravel.

If the air damper must be reset to meet the low fire air/fuel requirements, combustion at higher firing rates must be rechecked.

The second cam adjusting screw may need to be adjusted in order to maintain a smooth cam profile. If all screws are properly adjusted, none will deviate from the general overall contour of the cam face.

## R. LOW-GAS-PRESSURE SWITCH

Adjust the scale setting to slightly below the normal burning pressure. The control circuit will be broken when pressure falls below this point. Since gas line distribution pressure may



- 1. HI/LO GAS PRESSURE SENSOR (HAWK)
- 2. MAIN GAS VENT VALVE
- 3. MAIN GAS VALVES

Figure: 6-12 Gas Train Pressure Switches

decrease under some conditions, shutdowns may result if the setting is too close to normal. However, regulations require that the setting may not be less than 50% of the rated pressure downstream of the regulator.

Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored. Be sure that the mercury switch equipped control is level.

#### S. HIGH-GAS-PRESSURE SWITCH

Adjust the scale setting to slightly above the normal burning pressure. The control circuit will be broken when pressure exceeds the normal operating pressure. Unnecessary shutdowns may result if the setting is too close to normal; however, regulations require that the setting may not be greater than 150% of rated pressure.

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure falls. Be sure that the mercury switch equipped control is level.

# T. FUEL OIL PRESSURE AND TEMPERATURE - GENERAL

Variations in burning characteristics of the fuel oil may occasionally require adjustments to assure highest combustion efficiency. The handling and burning characteristics may vary from one delivery of oil to another. Therefore, it is recommended that the oil system be inspected

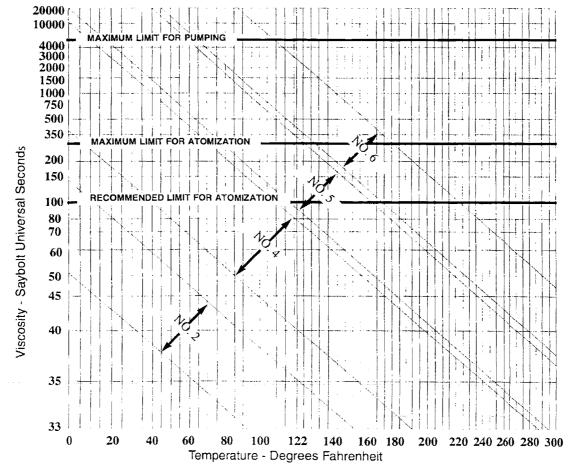


Figure: 6-13 Oil Viscosity Chart

from time to time to verify that pressures and viscosity are at the proper operating levels.

Because of variation in oils, including chemical content, source, blends, and viscosity characteristics, the temperatures and pressures listed in Chapter 5, and mentioned in the adjusting of the controls in the following paragraphs, will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. Figure 6-13 is an oil viscosity-temperature chart. It may be used as a guide, although your oil supplier will be able to give you more exact information based on an analysis of the oil.

Review of the applicable maintenance instructions given in Chapter 8 will aid in maintaining an efficient fuel system.

Note: To prevent oil heater coking, the fuel oil pump must be in operation during all times that an oil heater is in service. During any time that the oil pump is not operating, the oil heating system must be electrically shut down by manually turning the oil heater switch to the "off" position.

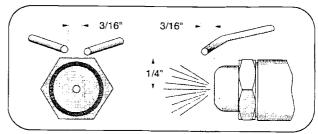


Figure: 6-14 Electrode Setting - Oil Pilot

When the boiler is shut down, or switched over to gas firing, the pump must operate for a sufficient period of time to cool the oil heater. Similarly, if an electric, steam, or hot water oil heater is removed for servicing, the temperature of the heater should be reduced by circulating oil until it has cooled.

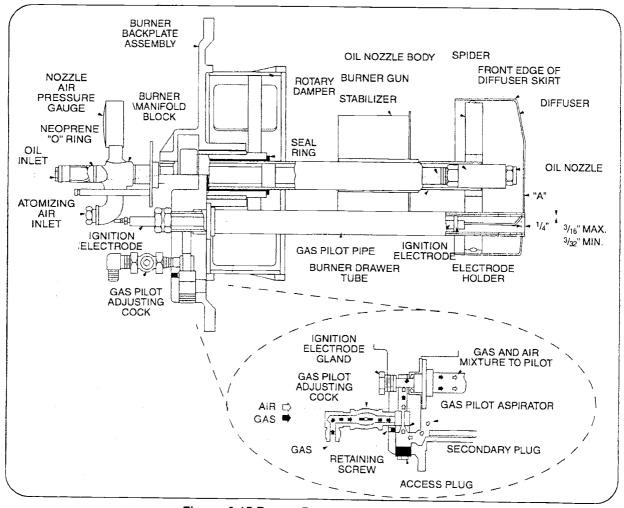
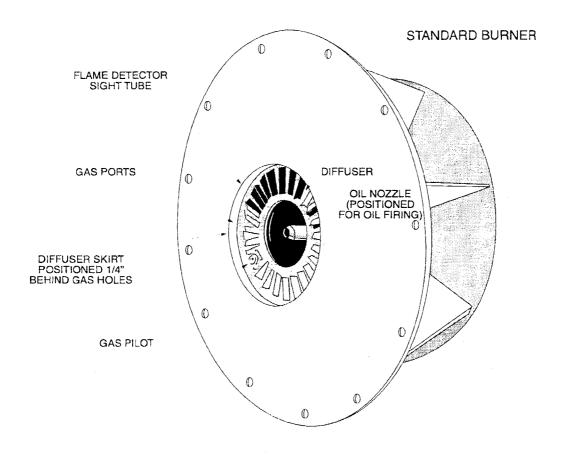


Figure: 6-15 Burner Drawer With Gas Pilot



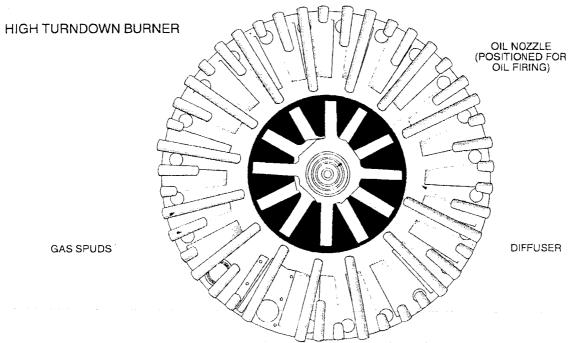


Figure: 6-16 Burner Housing

# U. FUEL OIL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

Note: All adjustment should be done by a qualified boiler operator or your local Cleaver-Brooks Service representative.

Burner efficiency is measured by the amount or percentage of O<sub>2</sub> present in the flue gas. O<sub>2</sub> readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room conditions and to ensure the combustion is on the proper side of the combustion curve (See Figure 6-9).

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. Efficient combustion cannot be solely judged by flame condition or color, although they may be used in making approximate settings. Combustion settings should be done so that there is a bright sharp flame with no visible haze.

Most flue gas analyzers in use today measure the content, by percentage, of oxygen  $(O_2)$  and in some cases, smoke. Carbon dioxide  $(CO_2)$  is not normally measured with modern gas analyzers, but may be displayed as a calculation.

The O<sub>2</sub> levels through the entire firing range of the burner, low fire to high fire should be tested. The burner manufactures recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

It is required to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure, temperature, or burning properties of oil. Fifteen to 20% excess air is considered reasonable. This would result in an O<sub>2</sub> reading of 3% to 4%, at high fire.

Final adjustment to fuel input must be made to produce a minimum of smoke. A maximum smoke spot density of a No. 2 for light oil, or a No. 4 for heavy oil is acceptable, as measured in conformance to ASTMD 2156-63T.

Through the use of the manual flame control, slowly bring the unit to high fire by stages while monitoring combustion for overly rich or lean conditions. At the high fire position, the air damper should be fully opened and the air and oil pressure readings should be on the order of the readings given in Chapter 5.

Take a flue gas analysis reading. If necessary, adjust the fuel oil controller to increase or decrease oil pressure. Adjustments to the pressure should be done before attempting to adjust the screws in the metering cam. Ideally, the cam

profile spring should be as close to the cam casting as practical. It is more desirable to lower the oil pressure to reduce flow, if necessary, than to extend the adjusting screws to an extreme position in an effort to cut back flow.

After being certain that the air control damper and its linkage are operating properly, final adjustment can be made, if necessary, to the oil modulating cam to obtain a constant fuel/air ratio through the entire firing range.

Note: Be sure the to loosen the cam foot locking screws before adjusting any cam screws or the cam feet may be damaged.

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of fuel at that setting. The adjustment is made to the metering cam by means of adjusting screws, which are turned out (counterclockwise from hex-socket end) to increase the flow of fuel and in (clockwise from hex-socket end) to decrease it. Flow rate is highest when the cam follower assembly is closest to the jackshaft. See Figure 6-11.

If oil pressure, primary air pressure, and linkages are properly adjusted, the metering cam should require minimal adjustment.

Using the flame control switch, position the cam so that the adjusting screw adjacent to the end, high-fire screw, contacts the cam follower. Make a combustion analysis at this point.

If an adjustment is necessary, turn the adjustment screw accordingly to increase or decrease fuel flow. Take a combustion reading to verify input. Repeat as necessary until the desired flow is obtained. Continue this pressure, stopping at each adjusting screw, until the low fire position is reached.

Note: Do not use any lubricant on the adjusting setscrews. These have a nylon locking insert intended to provide locking torque and resistance to loosening and a lubricant could damage the equipment.

# Standard Burner Low Fire Adjustment (Heavy Oil)

The fuel input should be adjusted with the low fire cam screw, to approximately 25% of that at high fire. At low fire the  $\rm O_2$  flue gas reading should be between 7-8%.

# High Turndown Burner Low Fire Adjustment (Light Oil)

Fuel input at low fire should be approximately 12.5% of that at high fire. The low fire screw-should be adjusted to obtain the necessary input for the fuel turndown required. At low fire the  $\rm O_2$  flue gas reading should be between 7-9%. The second cam adjusting screw may need to be adjusted in order to maintain a smooth cam profile.

#### V. BURNER DRAWER ADJUSTMENT

There are relatively few adjustments that can be made to the burner; however, a check should be made to assure that all components are properly located, and that all holding screws are properly tightened. Figures 6-17 and 6-18 show various views or portions of the burner.

The diffuser location on gas fired boilers is quite important. There should be 1/4" distance between the edges of the diffuser fins and gas outlet tubes (spuds)(see Figure 6-16). The setting of an oil fired burner is less exacting and the diffuser should be located with the skirt approximately 1-1/8" from the end of the burner tube.

When the proper diffuser location is ascertained, the setting of the nozzle in relation to the diffuser should be checked. This generally is set at time of manufacture and seldom needs altering. It is most important that oil spray does not impinge upon the diffuser. The distance that the nozzle is behind the diffuser has some latitude, and individual installations may require a slight deviation. The spacing indicated is 2".

Check the setting of the ignition electrode(s) for proper gap and position. See Figure 6-15 for the gas pilot electrode and Figure 6-14 for the light oil pilot. Be sure that the porcelain insulator is not cracked and that ignition cable connections are tight.

The oil nozzle tip should be seated tightly in the body with the swirler and the seating spring in place. See Section G in Chapter 8 for additional nozzle tip information.

Check to see that the flame detector sight tube and the gas pilot tube extend through their respective openings in the diffuser face.

#### W. OIL DRAWER SWITCH

The integral contacts of the control are closed by proper positioning and latching of the oil drawer in its forward position (Figure 6-17). Adjustment of the switch must be such that its contacts open if the oil drawer is not properly positioned for oil firing. The switch is electrically removed from the circuit when a combination fuel burner is fired on gas (Figure 6-18).

# X. LOW-OIL-TEMPERATURE SWITCH

The L.O.T.S. prevents the burner from starting, or stops its operation, if the temperature of the oil is below normal operating temperature.

To adjust the control, insert a screwdriver into the center slot in the control cover and turn the dial until the fixed (center) pointer is approximately 30°F lower than the oil heater thermostat setting. Turn the differential adjusting screw

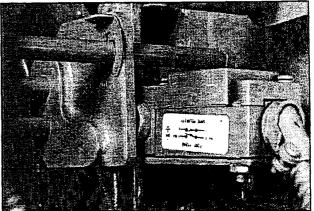


Figure: 6-17 Oil Gun In Place, Oil Draw Switch Closed

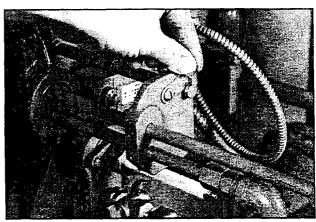


Figure: 6-18 Oil Gun Locked Out

(located above dial) until the movable indicator is approximately 5° F above the setting on the main scale.

On a hot water boiler, the low-oil-temperature switch is an integral part of the electric oil heater. The switch is non-adjustable and is factory set at approximately 40° F below the maximum operating temperature of the heater.

# Y. HIGH-OIL-TEMPERATURE SWITCH

The H.O.T.S. prevents the burner from starting, or stops its operation, if the temperature of the oil exceeds the normal operating temperature.

To adjust, turn the dial until the pointer is approximately 25° F above the normal operating temperature. The controls generally have a set differential and will close 5° F below the setpoint.

### Z. LOW OIL PRESSURE SWITCH

The L.O.P.S. prevents burner ignition, or stops its operation, when the oil pressure is below the set point. Adjust-the control by turning the screw on top of control case to an indicated pressure 10 psi below the established primary oil pressure setting indicated on the oil supply pressure gauge. The switch will remain in a closed position as long as the oil pressure exceeds this setting. The control normally used automatically resets when pressure is restored after a drop.

# AA. ELECTRIC OIL HEATER THERMOSTAT (400 and 600 Series Steam)

The maximum temperature setting of the control is stamped on the dial. The maximum Temperature setting is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of this thermostat should be at a temperature approximately 15° F lower than the steam heater thermostat. This eliminates the electric heater operation when the steam heater is functioning. The electric heater is sized to provide sufficient heated oil for low-fire operation on cold starts before steam is available.

## BB. STEAM OIL HEATER THERMOSTAT (No. 6 Oil) (400 and 600 Series - Steam)

The maximum temperature setting of the control is stamped on the dial. The maximum temperature setting is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of the thermostat should provide oil at a sufficient temperature for efficient combustion based on flue gas analysis. There is no need to heat the oil in excess of the temperature.

# CC. HOT WATER OIL HEATER THERMOSTAT (400 and 600 Series)

To adjust the thermostat, insert a screwdriver into the center slot in the control cover and turn the dial until the pointer is at the desired temperature level. The control generally has a set differential, and will close 5°F below the setpoint.

The thermostat contacts close to energize the booster water pump, which pumps water from the boiler through the heater. On cold starts, it is normal practice to manually close the valve in the pump discharge line until the boiler water temperature exceeds the temperature of fuel oil entering the heater.

The electric oil heater on a hot water boiler burning No. 6 oil and equipped with a hot water oil heater has a built-in adjustable thermostat. The maximum temperature setting is stamped on its dial. The desired temperature can be obtained by turning the adjusting screw. The thermostat should be set at a temperature approximately 15 degrees lower than the hot water heater thermostat. Such a temperature prevents the electric heater from operation when the water heater is functioning. The electric heater is sized to provide sufficient heated oil for low-fire operation on cold starts before hot water is available.

## DD. STEAM HEATER PRESSURE REGULATOR (400 and 600 Series -Steam)

The regulator is provided on a boiler designed to operate at pressures above 15 psi and reduces boiler steam pressure to the level necessary for proper operation of the steam oil heater. The pressure should be reduced to a point that permits sufficient temperature to heat the oil, while allowing as continuous a steam flow as possible. Pressure that is too high will result in frequent cycling of the steam solenoid valve.

It is best to adjust the regulator under typical flow conditions. To do so, it is suggested that the globe valve in the steam supply line be closed so that there is no pressure on the regulator. Turn out the adjusting screw fully to relieve compression on the regulator spring, thus closing the regulator. With steam at normal pressure, open the globe valve and then set the secondary pressure by turning the adjusting screw or handle until the downstream gauge shows the desired pressure.

# CHAPTER 7 TROUBLE SHOOTING

# **WARNING**

Trouble shooting should be performed only by personnel who are familiar with the equipment and who have read and understand the contents of this manual. Failure to follow these instructions could result in serious personal injury or death

## **A** WARNING

Disconnect and lock out the main power supply in order to avoid the hazard of electrical shock. Failure to follow these instructions could result in serious personal injury or death

Note: If your boiler is equipped with a CB-HAWK™ boiler management control system, refer to CB-HAWK Installation, Operating and Servicing Manual No. 750-133 for specific information regarding procedures described in this section

Chapter 7 assumes that the unit has been properly installed and adjusted, and that it has been running for some time. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points under each heading are set down briefly as possible causes, suggestions or clues to simplify locating the source of trouble. Methods of correcting the trouble, once it has been identified, may be found elsewhere in this manual.

If the burner will not start or operate properly, the trouble shooting Chapter should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies.

Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual. Knowledge of the system and its controls will make trouble shooting much easier. Costly down-time or delays can be prevented by systematic checks of actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

If an obvious condition is not apparent, check the continuity of the circuits with a voltmeter or test lamp. Each circuit can be checked and the fault isolated and corrected. Most circuitry checking can be done between appropriate terminals on the terminal boards in the control cabinet or the entrance box. Refer to the schematic wiring diagram for terminal identification.

Problem	Solution
BURNER DOES NOT	No voltage at program relay power input terminals.
START	A. Main disconnect switch open.
	B. Blown control circuit fuse.
	C. Loose or broken electrical connection.
	2. Program relay safety switch requires resetting.
	3. Limit circuit not completed—no voltage at end of limit circuit program relay terminal.
	A. Pressure or temperature is above setting of operation control. (Load demand light will not glow.)
	B. Water below required level.
	1). Low-water light (and alarm horn)should indicate this condition.
	Check manual reset button, if provided,     on low-water control.
	C. Fuel pressure must be within settings of low pressure and high pressure switches.
	D. Oil fired unit - burner gun must be in full forward position to close oil drawer switch.
	E. ) Heavy oil fired unit - oil temperature below minimum settings.
	4. Fuel valve interlock circuit not completed.
	A. Fuel valve auxiliary switch not enclosed.

NO IGNITION	1.	Lack of spark.
		A. Electrode grounded or porcelain cracked.
		B. Improper electrode setting.
		C. Loose terminal on ignition cable; cable shorted.
		D. Inoperative ignition transformer.
		E. Insufficient or no voltage at pilot ignition circuit terminal.
	2.	Spark but no flame.
		A. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc.
		B. Inoperative pilot solenoid.
		C. Insufficient or no voltage at pilot ignition circuit terminal.
		D. Too much air.
	3.	Low fire switch open in low fire proving circuit.
		A. Damper motor not closed, slipped cam, defective switch.
		B. Damper jammed or linkage binding.

Problem	Solution
	4. Running interlock circuit not completed.
	A. Combustion or atomizing air proving switches defective or not properly set.
	B. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

PILOT FLAME, BUT NO MAIN FLAME	1. Insufficient pilot flame.
	2. Gas Fired Unit.
	A. Manual gas cock closed.
	B. Main gas valve inoperative.
	C. Gas pressure regulator inoperative.
	3. Oil fired unit.
	A. Oil supply cut off by obstruction, closed valve, or loss of suction.
	B. Supply pump inoperative.
	C. No fuel.
	D. Main oil valve inoperative.
	E. Check oil nozzle, gun and lines.
	4. Flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.

BURNER STAYS IN LOW FIRE	1. Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor (see Section F).
	4. Defective modulating control.
	5. Binding or loose linkage, cams, setscrews, etc.

SHUTDOWN OCCURS DURING FIRING	1. Loss or stoppage of fuel supply.
	2. Defective fuel valve; loose electrical connection.
	3. Flame detector weak or defective.
	4. Lens dirty or sight tube obstructed.
	<ol> <li>If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.</li> </ol>

6.	If the programmer lockout switch has tripped:
	A. Check fuel lines and valves.
	B. Check flame detector.
	C. Check for open circuit in running interlock circuit.
	D. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.

Problem	Solution			
SHUTDOWN OCCURS DURING FIRING	7. Improper air/fuel ratio (lean fire).			
Borning Filling	A. Slipping linkage.			
	B. Damper stuck open.			
	C. Fluctuating fuel supply.			
	1). Temporary obstruction in fuel line.			
	2). Temporary drop in gas pressure.			
	3). Orifice gate valve accidentally opened (heavy oil).			
	8. Interlock device inoperative or defective.			

MODULATING MOTOR DOES NOT OPERATE	Manual-automatic switch in wrong position.	_
	Linkage loose or jammed.	_
	Motor does not drive to open or close during pre-purge or close on burner shutdow A. Motor defective.	/n.
	B. Loose electrical connection.	
· .	C. Damper motor transformer defective.	
	Motor does not operate on demand.	
	A. Manual/automatic switch in wrong position.	
	B. Modulating control improperly set or inoperative.	
	C. Motor defective.	
	D.Loose electrical connection.	
	E. Damper motor transformer defective.	

# CHAPTER 8 INSPECTION AND MAINTENANCE

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Note: For more information on your flame safeguard system, refer to the appropriate manual that was provided with your boiler

## **A** CAUTION

Inspection and maintenance should be performed only by trained personnel who are familiar with this equipment. Failure to follow these instructions could result in equipment damage

#### A. GENERAL

A well-planned maintenance program will help avoid unnecessary down-time or costly repairs, promote safety, and aid boiler inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly, and yearly maintenance activities provides a valuable guide and aids in obtaining economical and lengthy service from Cleaver-Brooks equipment. A boiler inspection schedule is shown in Figure 8-30. It is important to realize that the frequency of inspection will depend on variable conditions: such as load, fuel, system requirements, boiler environment (indoor/outdoor) etc.

Good housekeeping helps maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust, or repair the boiler and its related equipment. The boiler room should be kept free of all material and equipment not necessary to the operation of the boiler or heating system.

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Even though the boiler has electrical and mechanical devices that make it automatic or semi-automatic in operation, the devices require systematic and periodic maintenance. Any automatic feature does not relieve the operator from responsibility, but rather frees the operator from certain repetitive chores providing time to devote to upkeep and maintenance.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction and permit prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks - fuel, water, steam, exhaust gas - should be repaired promptly and under conditions that observe necessary safety precautions. Preventive maintenance measures, such as regularly checking the tightness of connections, locknuts, setserews, packing glands, etc., should be included in regular maintenance activities.

## **Periodic Inspection**

Insurance regulations and local laws require periodic inspection of the pressure vessel by an authorized inspector. Section H of Chapter 3 contains information relative to the inspection.

Inspections are usually, though not necessarily, scheduled for periods of normal boiler down time, such as an off season. This major inspection can often be used to accomplish maintenance, replacement or repairs that cannot easily be done at other times. Inspection also serves as a good basis for establishing a schedule for annual, monthly, or other periodic maintenance programs.

While the inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the operator an excellent opportunity for detailed inspection and

#### Chapter 8

check of all components of the boiler including piping, valves, pumps, gaskets, refractory, etc. Comprehensive cleaning, spot painting or repainting, and the replacement of expendable items should be planned for and taken care of during this time. Any major repairs or replacements that may be required should also, if possible, be coordinated with the period of boiler shutdown.

Replacement spare parts, if not on hand, should be ordered sufficiently prior to shutdown.

Note: Cleaver-Brooks genuine parts should be used to ensure proper operation. Contact your local Cleaver-Brooks representative for parts information and ordering

Cleaver-Brooks boilers are designed, engineered, and built to provide long life and excellent service. Good operating practices and conscientious maintenance and care will assure efficiency and economy from their operation, and will contribute to many years of performance.

A total protection plan includes a Planned Maintenance Program that covers many of the items included in this chapter.

For information regarding a total protection plan, contact your local Cleaver-Brooks authorized representative.

#### **B. FIRESIDE CLEANING**

Soot and non-combustibles are effective insulators, and, if allowed to accumulate, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can be very moisture-absorbent, and may attract moisture to form corrosive acids that will deteriorate fireside metal.

Clean-out should be performed at regular and frequent intervals, depending upon load, type, and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer can be used as a guide to clean-out intervals since an accumulation of soot deposits will raise the flue gas temperature.

Tube cleaning is accomplished by opening the front and rear doors. Tubes may be brushed from either end. All loose soot and accumulations should be removed. Any soot, or other deposits, should be removed from the furnace and tube sheets.

Refer to Section Q of Chapter 8 for instructions on properly closing rear heads.

The flue gas outlet and stack should be inspected annually and cleaned as necessary. Commercial firms are available to perform the work. The stack should be inspected for damage and repaired as required.

The fireside should be thoroughly cleaned prior to any extended lay-up of the boiler. Depending upon circumstances, a protective coating may be required. See Section I in Chapter 3.

#### C. WATER LEVEL CONTROLS

The need to periodically check water level controls and the waterside of the pressure vessel cannot be overemphasized. Most instances of major boiler damage are the result of operating with low water, or the use of untreated (or incorrectly) treated water.

Always be sure of the boiler water level. On steam boilers, the water column should be blown down daily. Check samples of boiler water and condensate in accordance with procedures recommended by your local Cleaver-Brooks authorized representative. Refer to Sections G and H in Chapter 3 for blowdown instructions and internal inspection procedures.

Since low-water cutoff devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low-water cutoff or point of pump cut-in or cut-out. If a low-water device should become erratic in operation, or if its setting changes from previously

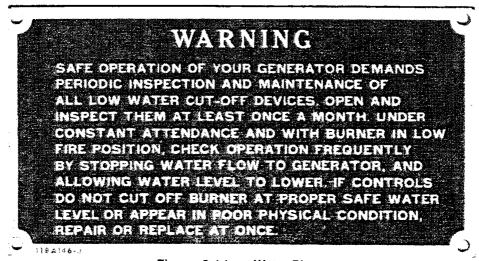


Figure: 8-1 Low-Water Plate

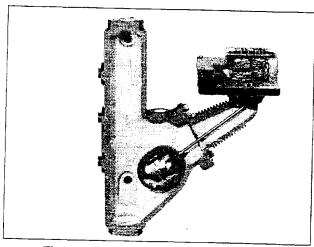


Figure 8-2: Low Water Cutoff - Cutaway

established levels, contact your local Cleaver-Brooks authorized representative.

#### Steam Boiler

Figure 8-1 shows the low-water cutoff plate which is attached to a steam boiler. The instructions should be followed on a definite schedule. The controls normally function for long periods of time, which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

On a steam boiler, the head mechanism of the low-water cutoff device(s) should be removed from the bowl at least semi-annually to check and clean the float ball, the internal moving parts, and the bowl or water column. Figure 8-2 shows a cutaway of the low water cutoff.

Remove the pipe plugs from the tees or crosses and make certain the cross-connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance. Determine that piping is vertically aligned after shipment and installation and throughout life of equipment.

A blowdown of the water controls on a steam boiler should be performed daily

#### Hot Water Boiler.

It is impractical to blowdown the low-water cutoff devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require make-up and additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangement usually make it impractical to perform daily and monthly maintenance of the low-water cutoff devices, it is essential to verify proper operation. Remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float ball, internal moving parts, and the bowl housing. Also check the cross-connecting piping to be certain that it is clean and free of obstruction.

## D. WATER GAUGE GLASS

A broken or discolored glass should be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use loose packing, which could be forced below the glass and possibly plug the valve opening.

Close the valves when replacing the glass. Slip a packing nut, a packing washer, and packing ring onto each end of the glass. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.

It is recommended that the boiler is off and cool when the glass is replaced. However if the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by opening the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.



Do not attempt to change the gauge glass while the boiler is in service. Failure to follow these instructions could result in serious personal injury or death

Check try-cocks and gauge cocks for freedom of operation and clean as required. It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

## E. ELECTRICAL CONTROLS

The operating controls should be inspected monthly. Examine tightness of electrical connections and keep the controls clean. Remove any dust that accumulates in the interior of the control using a low pressure air. Take care not to damage the mechanism.

Examine any mercury tube switches for damage or cracks. Dark scum over the normally bright surface of the mercury, may lead to creatic switching action. Be certain that controls are correctly leveled. The piping leading to the pressure control actuators should be cleaned, if necessary. Covers should be left on controls at all times.

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts. Use a burnishing tool or a hard surface paper to clean and polish contacts. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Replacement of the contacts is necessary only if the silver has worn thin.

ELECTRICAL LOAD	SINGLE PHAS	E 50/60 HERTZ		THRE	E PHASE 50/60	HERTZ		
	110-120 V	220-240 V	200-208 V	220-240 V	346-416 V	440-480 V	550-660 V	
1/4 HP MOTOR	FRN-8	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10		FRS-1	FRS-8/10	
1/3 HP MOTOR	FRN-9	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10		FRS-1	FRS-8/10	
1/2 HP MOTOR	FRN-12	FRN-6-1/4	FRN-2-8/10	FRN-2-8/10	FRS-1-8/10	FRS-1-4/10	FRS-1	
3/4 HP MOTOR	FRN-17-1/2	FRN-9	FRN-4-1/2	FRN-4-1/2	FRS-2-1/4	FRS-1-8/10	FRS-1-4/10	
1 HP MOTOR	FRN-20	FRN-10	FRN-5	FRN-5	FRS-3-2/10	FRS-2-1/4	FRS-1-8/10	
1-1/2 HP MOTOR	FRN-25	FRN-12	FRN-7	FRN-7	FRS-4	FRS-3-2/10	FRS-2-1/2	
2 HP MOTOR	FRN-30	FRN-15	FRN-9	FRN-9	FRS-5-6/10	FRS-4-1/2	FRS-3-1/2	
3 HP MOTOR	FRN-40	FRN-20	FRN-12	FRN-12	FRS-8	FRS-6-1/4	FRS-5	
5 HP MOTOR		FRN-35	FRN-20	FRN-20	FRS-12	FRS-10	FRS-8	
7-1/2 HP MOTOR		FRN-50	FRN-30	FRN-30	FRS-17-1/2	FRS-15	FRS-12	
10 HP MOTOR		FRN-60	FRN-40	FRN-35	FRS-20	FRS-17-1/2	FRS-15	
15 HP MOTOR			FRN-60	FRN-50	FAS-30	FRS-25	FRS-20	
20 HP MOTOR			FRN-70	FRN-70	FRS-40	FRS-35	FRS-25	
25 HP MOTOR			FRN-90	FRN-80	FRS-50	FRS-40	FRS-35	
30 HP MOTOR		, , ,	FRN-100	FRN-100	FRS-60	FRS-50	FRS-40	
40 HP MOTOR			FRN-150	FRN-150	FRS-80	FRS-70	FRS-50	
50 HP MOTOR			FRN-175	FRN-175	FRS-100	FRS-80	FRS-70	
60 HP MOTOR			FRN-200	FRN-200	FRS-125	FRS-100	FRS-80	
75 HP MOTOR			FRN-250	FRN-250	FRS-150	FRS-125	FRS-100	
100 HP MOTOR			FRN-350	FRN-300		FRS-150	FRS-125	
125 HP MOTOR			FRN-450	FRN-400	† — — —	FRS-200	FRS-150	
150 HP MOTOR			FRN-500	FRN-450		FRS-225	FRS-200	
200 HP MOTOR				FRN-600		FRS-300	FRS-250	
2 KW HEATER	FRN-20	FRN-12	FRN-7	FRN-7		FRS-4-1/2	500000	
3 KW HEATER	FRN-30	FRN-15	FRN-10	FRN-10	FRS-6-1/4	+	FRS-3-2/10	
5 KW HEATER	FRN-50	FRN-25	FRN-15	FRN-15	FRS-10	FRS-5-6/10	FRS-4-1/2	
7-1/2 KW HEATER			FRN-25	FRN-25		FRS-8	FRS-6-1/4	
10 KW HEATER			FRN-30	FRN-30	FRS-15 FRS-25	FRS-12 FRS-17-1/2	FRS-10	
15 KW HEATER			FRN-45	FRN-45	FRS-35			
ONTROL CIRCUIT XFMR VOLTAGE	1/2 KVA	4.	1 KVA.	1111-45	1-1/2 KVA.	FRS-25	FRS-20 KVA.	
110-120	FRN-7		FRN-15					
200-208	FRN-4		FRN-8		FRN-17-1/2 FRN-12	FRN-2		
220-240	FRN-3-1/2		FRN-7		FRN-10	FRN-1		
346-416	FRS-2-8/1	0	FRS-4		FRS-6-1/4	FRN-1	<del></del>	
440-480	FRS-2-1/2		FRS-3-1/2			FRS-8		
550-600	FRS-2		FRS-3-1/2		FRS-5-6/10		FRS-7	
SECONDARY FUSE			FRN-12				RS-5-6/10	
			REERING DEPT. FOR "FUSETRON"		FRN-15	FRN-20		

Figure 8-3: Recommended Maximum "Fusetron" Fuse Sizes

## **A** CAUTION

Do not use files or abrasive materials such as sandpaper on the contact points. Failure to follow these instructions could result in equipment damage.

Thermal relay units (overloads) are of the melting-alloy type and, when tripped, the alloy must be given time to re-solidify before relay can be reset. If the overloads trip out repeatedly when the motor current is normal, replace them with new overloads. If the condition continues after replacement, it will be necessary to determine the cause of excessive current draw at the overloads.

Power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended. Information given in Figure 8-3 is included for guidance to fuse requirements.

## F. FLAME SAFETY CONTROL

The microprocessor based control requires minimal maintenance because the safety and logic timings are inaccessible. There also are not any accessible contacts. Check to see that the retaining screw is securely holding the chassis to the mounting base. Also check to see that the amplifier and the program module are tightly inserted.

The relay's self-diagnostic ability includes advising when it or its plug-in modules are at fault and require replacement.

Your spare control should be stored in a dry atmosphere and wrapped in plastic. During an extended shutdown (e.g., seasonal), the active control should be removed and stored. Moisture can cause problems with control operation.

It is recommended that service be rotated between the active and a spare control to assure a working replacement is available.

## **A** WARNING

When replacing a control, be sure to lock out the main power supply switch since the control is "hot" even though the burner switch is off. Failure to follow these instructions could result in serious personal injury or death.

Be sure the connecting contacts on the control and its base are not bent out of position.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth moistened with detergent to clean the lens.

A safety check procedure should be established to test the complete safeguard system at least once a month, or more often. Tests should verify safety shutdown and a safety lockout upon failure to ignite the pilot, upon failure to ignite the main flame, and upon loss of flame. Each of the conditions should be checked on a scheduled basis.

The following tests should be used to test the complete safeguard system. If the sequence of events is not as described, then a problem may exist. Contact your local Cleaver-Brooks authorized representative for assistance.

## **Checking Pilot Flame Failure**

Close the gas pilot shutoff cock (Figure 2-10). Also shut off the main fuel supply. Turn the burner switch "on,"

The pilot ignition circuit will be energized at the end of the pre-purge period. There should be an ignition spark, but no flame. Since there is no flame to be detected, the program relay will signal the condition. The ignition circuit will deenergize and the control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Reopen the gas pilot shutoff cock and re-establish main fuel supply.

## Checking Failure to Light Main Flame

Leave the gas pilot shutoff cock open. Shut off the main burner fuel supply. Turn the burner switch on. The pilot will light upon completion of the pre-purge period. The main fuel valve(s) will be energized, but there should be no main flame.

The fuel valve(s) deenergize within 4 seconds after the main burner ignition trial ends. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Reestablish main fuel supply.

#### **Checking Loss of Flame**

With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame.

The fuel valve(s) will be deenergized and the relay will signal the condition within 4 seconds. The control will then lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Reestablish main fuel supply.

# G. OIL BURNER MAINTENANCE

The burner should be inspected for evidence of damage due to improperly adjusted combustion. Any soot buildup on the diffuser or the oil nozzle should be removed. The setting of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked. See Section T in Chapter 6.

#### Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel.

#### **Light Oil Strainers**

The fuel oil strainer screen must be removed and cleaned at regular intervals. It is advisable to remove the screen each month and clean thoroughly by immersing it in solvent and blowing it dry with compressed air. To remove, loosen the cover cap screw, being careful not to lose the copper gasket. If necessary, tap the strainer cover gently to loosen. Check the cover gasket for damage and replace if necessary. Slip pliers into the cross on the top of the strainer and twist counterclockwise to remove the basket. Reassemble in reverse order.

#### **Heavy Oil Strainers**

Keep the cartridge of the oil strainer clear by regularly giving the exterior handle one complete turn in either direction. Do this often until experience indicates cleaning frequency necessary to maintain optimum conditions of flow. If the handle turns hard, rotate the handle back and forward until it can be turned through a complete revolution. Do not force it with a wrench or other tool.

Drain the sump as often as experience indicates the necessity. Remove the sump, or the head and cartridge assembly, for thorough cleaning and inspection at frequent intervals. Exercise care not to damage the cartridge discs or the cleaner

blades. Wash the cartridge in solvents. Do not attempt to disassemble the cartridge.

#### Cleaning Oil Nozzle

The design of the burner, together with the oil purge system on a heavy oil burner, make it unnecessary to clean the oil nozzle during periods of operation. A routine check and any necessary cleaning should be made during off periods or when the burner is firing on gas.

If at any time the burner flame appears "stringy" or "lazy," it is possible that the nozzle tip or swirler has become partially clogged or worn. Any blockage within the tip will cause the air pressure gauge to increase above its normal value.

Disassemble with the power off by unlatching and withdrawing the burner gun. Insert the nozzle body into the hanger vice and use the spanner wrench to remove the tip. Carefully remove the swirler and seating spring being careful not to drop or damage any parts. See Figure 8-4, 8-5.

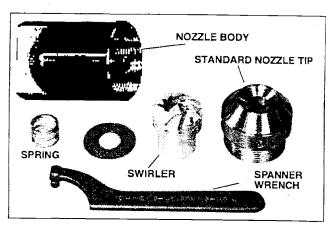


Figure 8-4: High Turndown Nozzle Components

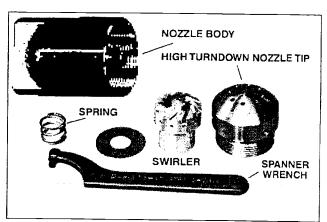


Figure 8-5: CB-LE Burner Nozzle Components

Perform any necessary cleaning with a suitable solvent. Use a soft fiber brush or pointed piece of soft wood for cleaning. Do not use wire or a sharp metallic object, which could scratch or deform the orifices as well as the precision ground surfaces of the swirler and tip. Inspect for scratches or signs of wear or erosion, which may make the nozzle unfit for further use. Take the necessary precautions in working with solvents.

The tip and swirler are a matched set, which are precision lapped at the time of assembly. The close fit of the lapped surfaces must be maintained in order to provide optimum performance. Additional lapping may be required to provide better atomization for more efficient combustion. Do not interchange parts if a spare is kept. In reassembling, be certain that the scating spring is in place and that it is holding the swirler tightly against the tip. The swirler is stationary and does not rotate, but rather imparts a swirling motion to the oil.

See that the plugged hole is at the bottom of the nozzle body when the gun is installed.

# Cleaning Air Purge Nozzle (No. 6 Oil) and Back Pressure Orifice Nozzle (No. 2 Oil)

The air purge nozzle and its strainer should be inspected periodically and cleaned. The nozzle consists of a tip and internal core. Clean all internal surfaces of the tip and the slotted parts of the core using a wood splinter to avoid damage from scratching. Replace the core, setting it tightly but not excessively so.

Clean the strainer screen carefully to remove any foreign matter. Use suitable solvents in cleaning. Extremely hot water at high velocity is also helpful in cleaning. Replace strainer by screwing it into the nozzle body only finger tight. Do not use an orifice of a size other than originally installed.

#### Ignition System

For best results, maintain the proper gap and dimensions of the ignition electrode(s). Figures 6-14 & 6-15 show the proper settings.

Inspect the electrode tip for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the porcelain insulator (s) for any cracks that might be present. If there are cracks, replace the electrode since they can cause grounding of the ignition voltage. Since carbon is an electrical conductor, it is necessary to keep the insulating portion of electrode(s) wiped clean if any carbon is present. Ammonia will aid in removing carbon or soot.

Check ignition cables for cracks in the insulation. Also see that all connections between the transformer and the electrodes are tight.

Periodically remove the access plug from the gas pilot aspirator (Figure 6-15) and clean out any accumulated lint or other foreign material.

## H. GAS BURNER MAINTENANCE

The gas burner components should be inspected for evidence of damage due to improperly adjusted combustion. Combustion adjustments should be checked monthly. See Section T in Chapter 6.

Check periodically for a proper seal between the end of the burner housing and boiler refractory (see Figure 8-24). Any deterioration of the seal should be corrected, as an improper or poor seal allows air leaks, which can cause overheating or burning of the burner housing.

Whenever the burner is removed, the diffuser, gas housing and gas spuds (HTB model only) should be checked for any deterioration. Verify that the diffuser skirt conforms to the bore of the burner housing so as to minimize the amount of combustion air which bypasses the diffuser. If the burner is a high turndown burner (HTB) model, check to see that the diffuser is properly located in reference to the gas spuds. There should be 1/4" between the edge of the diffuser fins and the gas spuds when the burner is installed. Check to see that the diffuser fins do not interfere with the gas ports or gas spuds in the burner housing (see Chapter 6, Figure 6-16). See Section V in Chapter 6 for more information.

Check the electrode setting for any cracks that might be present on the porcelain insulator. Replace the electrode if cracking is evident, since cracking can cause grounding of the ignition voltage. Inspect the tip of the electrode for signs of pitting, combustion deposits and wear, and dress as required with a fine file. See Chapter 6, Figure 6-14 & 6-15 for electrode settings.

Periodically remove the access plug from the gas pilot aspirator (see Chapter 6, Figure 6-15) and clean out any accumulated lint or other foreign material.

Check the ignition cables for cracks in the insulation. Verify that all connections between the transformer and the electrode are tight.

# I. MOTORIZED GAS VALVE

The motorized gas valve (Hydramotor) operating mechanism is completely immersed in oil and little maintenance is required because of the scaled design. However, proper operation should be checked on a routine periodic basis.

Keep outer parts of the valve clean, especially the stem between the operator and the valve. A nicked, scored or otherwise damaged valve stem can cause leakage. Do not remove dust covers if installed. The packing gland is of the O-ring type. If oil is noticed around the operator base or if leakage occurs, repair by replacing any leaking O-rings and refilling the actuator with oil.

If the actuator is sluggish or fails to operate, even after the oil level is checked, replace the entire operator portion.

#### J. SOLENOID VALVES

Foreign matter between the valve seat and seat disc can cause leakage. Valves are readily disassembled; however, care must be used during disassembly to be sure that internal parts are not damaged during the removal and that reassembly is in proper order.

A low hum or buzzing will normally be audible when the coil is energized. If the valve develops a loud buzzing or chattering noise, check for proper voltage and clean the plunger assembly and interior plunger tube thoroughly. Do not use any oil. Be sure that the plunger tube and solenoid are tight when reassembled. Take care not to nick, dent, or damage the plunger tube.

Coils may be replaced without removing the valve from the line.

# **WARNING**

Be sure to turn off power to the valve in order to avoid electrical shock. Failure to follow these instructions could result in serious personal injury or death.

Check coil position and make sure that any insulating washers or retaining springs are reinstalled in proper order.

## K. AIR CONTROL DAMPER, LINKAGE AND CAM SPRING

The burner air control damper should be checked for free movement as a part of the monthly inspection. With the burner off and the jackshaft damper control rod disconnected, the air control damper should rotate freely through its entire range of movement. Any resistance to movement or excessive play in the support bearing should be investigated and corrected before the burner is put back in operation.

The overall tightness of the linkage assembly should be checked monthly. If necessary, tighten the setscrews and the connections at the uniballs. Check the uniballs for wear and replace if necessary.

The linkage assembly should be tight but should not bind. If the linkage assembly is binding, determine the cause of the binding and correct as necessary. Linkage rod end attachment points should be marked on the variable displacement linkage arms as an aid in subsequent reassembly.

Inspection of the air damper and linkage bearings should be performed on a more frequent basis if the boiler is operating in a dirty environment.

The fuel cam profile spring should be inspected monthly for wear, scoring or distortion. If any of the questionable conditions are found, the spring must be replaced immediately to avoid the possibility of breakage in service. Use care to avoid damaging the cam or spring during installation.

Lubricate occasionally with a non-gumming, dripless, hightemperature lubricant such as graphite or a silicone derivative.

#### **A** CAUTION

Combustion should be checked and readjusted as required whenever the burner is removed or any control linkage is disturbed. Failure to follow these instructions could result in equipment damage.

#### L. FORCED DRAFT FAN

Figure 8-6 illustrates the forced draft fan and motor mounting in relation to the fan housing. The position of the fan housing and the clearance between it and the fan (impeller) is extremely important to the output capacity of the fan.

The following procedures for installing and adjusting are as follows:

- 1. Bolt the motor securely to the head.
- 2. Slide the fan onto the shaft, but do not tighten the setscrews.
- Turn the spacers on the studs until they contact the headplate.
- Place external tooth lockwashers next to the spacers and install the fan housing on the studs. Hold the fan housing in place with nuts and lockwashers. Finger tighten the nuts.
- Slide the impeller outward until its vanes contact the fan housing. The housing must be parallel to the impeller. Adjust the spacers as necessary to align the housing with the impeller.
- 6. Slide the impeller toward the motor. Use a feeler gauge to obtain .030-.050" clearance between the impeller and the housing.
- 7. Secure the key and then tighten the impeller hub setscrews. Using a selected vane, rotate the impeller

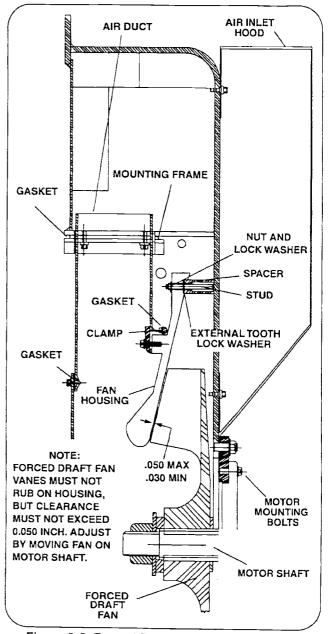


Figure 8-6: Forced Draft Fan Mounting (CB-LE)

while checking to see that the clearance between the impeller and the housing remains constant and within the specified 0.030-0.050" clearance.

- Install the air duct assembly through the head opening.
  Tighten the screws securing the air duct to the fan
  housing only enough to create a seal between the
  neoprene gasket and the housing.
- After connecting the motor leads, verify that the impeller rotation is counter-clockwise when viewed from the motor end.

# M. FAN/MOTOR CASSETTE REMOVAL

Before the boiler is commissioned at the job site, the IFGR system should be visually inspected. The fan/motor cassette should be removed to expose the internal IFGR linkage and damper. Remove the fan/motor cassette as follows:

# **A** WARNING

Disconnect and lock out electrical power to the boiler before removing the fan/motor cassette. Failure to follow these instructions can result in electrical shock and serious personal injury or death.

- 1. Disconnect and lock out electric power to the boiler.
- 2. Be sure that the front door is securely bolted to the boiler

# **A** WARNING

Do not remove the davit arm assembly without first ensuring that the front door is securely bolted to the boiler. Failure to follow these instructions can result in serious personal injury or death.

3. Release the davit arm by removing the retaining bolt at the top center of the boiler.

## **WARNING**

When suspending the fan/motor cassette from the davit arm, all equipment used must be of adequate strength to safely support the complete cassette. Failure to follow these instructions can cause injury or death.

## **A** WARNING

Chains or other devices used to attach a lifting device to the fan/motor cassette must be arranged so the cassette does not rotate or tilt when removed from the front head. Failure to follow these instructions could result in damage to attachment.

4. Connect the davit arm to the fan/motor cassette using the suspension system diagramed in figure 8-8.

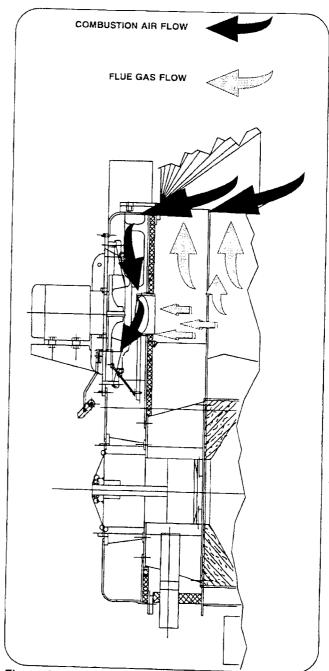


Figure 8-7: IFGR Combustion Air and Flue Gas Flow

- Arrange the attaching chains so the lifting point is over the motor shaft centerline and the center of balance for the fan/ motor cassette. This point is approximately 3-inches for 250-500 hp units.
- 6. Remove the fan/motor cassette fastening nuts (Figure 8-9).

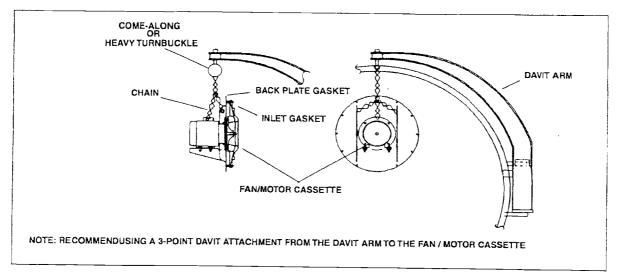


Figure 8-8: Fan/Motor Cassette

### **A** CAUTION

Be sure that the fan motor wiring and conduit are not stretched during the fan/motor cassette removal. Failure to follow these instructions can result in damage to the equipment.

 Swing the fan/motor cassette to the side and secure it to the boiler using high strength cord. Do not over extend the motor wires.

#### N. INSPECTION AND ADJUSTMENT

NOx levels should be checked periodically to ensure compliance with all local and federal regulations, as well as to ensure that the boiler is operating at maximum efficiency. Linkages should be inspected and free movement (no binding) of the IFGR damper confirmed.

Increasing or decreasing NOx levels could indicate incorrect damper positioning, loose linkages, an improper air-to-fuel ratio, or stack draft changes. If adjustment is required, or if problems persist, contact your local Cleaver-Brooks authorized representative for further assistance.

As ash and products of combustion pass through the IFGR damper, there will be some accumulation on the damper, windbox, and other parts of the IFGR system and burner.

To ensure proper operation of the IFGR system and burner, inspection and cleaning should be performed at regular intervals, depending on the load, type of fuel, and combustion temperatures.

- With the IFGR damper exposed, inspect the internal linkages for secure connections, and check for free movement of the linkage arms and the IFGR damper assembly. To check for free movement of the linkage separate the external linkage from the jackshaft drive arm(s) and cycling the exterior linkage through its range of movement.
- 2. The clearance between the impeller and backplate should be checked, and adjusted, if required. Impeller clearances must be as shown in Table 8-1.
- 3. The impeller clearance is checked by inserting a long feeler gauge of the proper thickness between the impeller and the impeller housing. Impeller clearances should be checked at the highest fin on the impeller (that fin which is closest to the impeller housing), and must be checked at each point where the housing is attached to the motor backplate.
- 4. If the impeller clearance is not correct at all points, make adjustments as follows:
  - A. Loosen the retaining nuts on both sides of the impeller housing.
  - B. Adjust the retainers for the correct impeller clearance at two housing attachment points 180° apart.

STANDARD 60 PPM	30 PPM 25 PPM	20 PPM		
.040 ±.010	0.050 +.010/005	.060 +.005/000		

Table 8-1. Impelier Clearances

- C. Adjust the retainers for correct clearance at the housing attachment points 90° from those initially adjusted.
- D. Adjust for correct impeller clearance at the remaining attachment points.
- Check and replace any gaskets that have been damaged. Gaskets that have been in use for one year or more should

be replaced. In particular, inspect the airbox gasket (Figure 8-9) for damage. If it needs to be replace, refer to Section O for installation instructions.

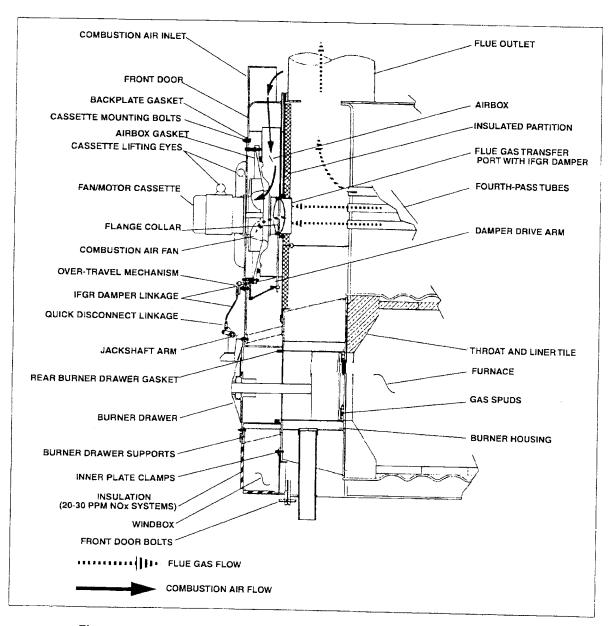


Figure 8-9: Induced Flue Gas Recirculation System, General Arrangement

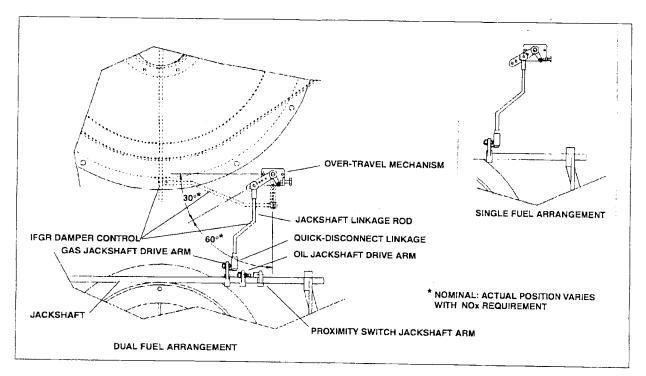


Figure 8-10: IFGR Damper Linkage

### O. AIRBOX GASKET INSTALLATION

If the fan/motor cassette is opened for any reason after the unit has been in operation for one year, the airbox gasket should be replaced.

#### **A** CAUTION

When replacing the airbox gasket, use only Cleaver-Brooks components. Failure to use components designed for this application can result in improper combustion. Failure to follow these instructions can result in equipment damage

Attach the airbox gasket to the inlet box with hightemperature silicone adhesive/sealant, using two beads of silicone about 1/4" in from each side of the gasket (gasket surface is 2" wide).

- 6. Secure the gasket in position with clamps, using strips of wood on top of the gasket for a bearing surface.
- 7. After the silicone has dried (approximately 24 hours), remove the clamps and strips of wood.

# P. FAN/MOTOR CASSETTE INSTALLATION

The fan/motor cassette can be closed as follows:

- Check that all adjustment screws are tight, and check the linkage and IFGR damper for free movement before closing the unit.
- 2. Position the cassette into the front door.

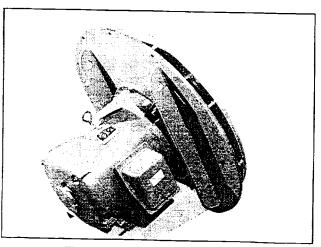


Figure 8-11: Fan/Motor Cassette

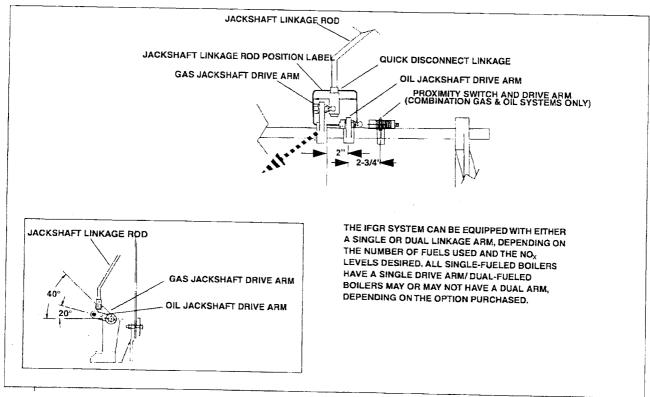


Figure 8-12: Jackshaft Linkage Settings

- 3. Slide the cassette into position until it begins to contact the inlet gasket (Figure 8-9) then measure the clearance between the cassette flange and the front door mounting face. There must be clearance of at least 1/4" to provide adequate gasket compression when the cassette is mounted tightly to the door.
- 4. Secure the cassette with the fastening nuts.

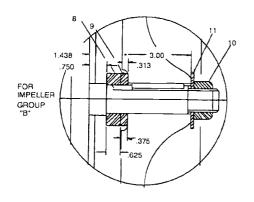
## **A** WARNING

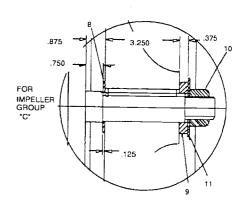
Do not remove the davit arm assembly from the motor/fan cassette without first verifying that the cassette is securely bolted to the boiler. Failure to follow these instructions can result in serious personal injury or death.

5. After the cassette has been secured to the front head, reconnect the davit to the front door by screwing in the retaining bolt at the top centerline.

Check occasionally that the fan is securely tightened to the motor shaft. Check the clearance between the fan vanes and housing as outlined above.

SEE SHEET 2 FOR TABLES AND PROCEDURES.





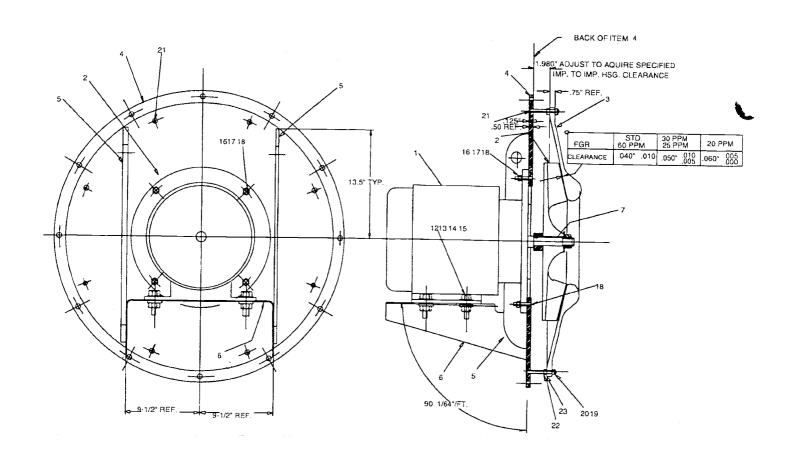


Figure 8-13: Blower Cartridge Assembly 1 of 2

			BASIC BIL	L OF MATERIAL 78" DIA 250 THRU 350	(& 400 78")
	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
4	1	1	TABLE	BLOWER MOTER	
. 'سد	2	1	TABLE	IMPELLER - OPEN TYPE	
	3	1	40-C-618	HOUSING - IMPELLER	-
	1 4	1	003-B-1091	BASE, MOUNTING	7.5-15 MTR H.P.(D.P.)
					7.5-10 MTR H.P. (TEFC
	4	1	003-1092	BASE, MOUNTING	20-40 MTR H.P.(D.P.)
					15-30 MTR H.P. (TEFC
	4	1	003-1256	BASE, MOUNTING	50 MTR H.P.(D.P.)
	$\vdash$				40-50 MTR H.P. (TEFC)
	5	2	004-A-460	BAR, REINFORCING/LIFTING LUG	
	6	0	n√a	SUPPORT, MOTOR	0-20 MTR H.P.
	6	1	085-03120	SUPPORT, MÖTÖR (085-03120)	30-40 MTR H.P
	7	1	841-0****	KEY (1/4" SQ. X 2-1/2" LG.)	0-7.5 MTR H.P.
	7	1	841-01105	KEY (5/16" SQ. X 2-1/2" LG.)	10-40 MTR H P
<b>O</b> R	8	2	077-00433	SPACER- 5/8' THK. (077-B-00432)	0-7.5 MTR H.P.
MPELLER	В	2	077-00445	SPACER- 5/8" THK. (077-B-00432)	10-30 MTR H.P.
PLOB	8	2	077-00446	SPACER- 5/8" THK (077-B-00432)	40-75 MTR H.P.
Α-	9	0	n/a		
	8	1	077-00433	SPACER 5/8" THK (077-B-00432)	0-7.5 MTR H.P
OR	8	1	077-00445	SPACER- 5/8" THK. (077-B-00432)	10-30 MTR H.P.
PELLER	8	1	077-00446	SPACER- 5/8" THK. (077-B-00432)	40-75 MTR H.P.
ROUP	9	1	077-00451	SPACER- 3/8" THK. (077-B-00432)	0-7.5 MTR H,P
В,	9	1	077-00432	SPACER- 3/8" THK (077-B-00432)	10-30 MTR H.P.
	9	1	007-00434	SPACER- 3/8" THK. (077-B-00432)	40-75 MTR H.P
DFI.	8	1	077-00436	SPACER- 1/8" THK. (077-B-00432)	10-30 MTR H.P.
IPELLER	8	1	077-00437	SPACER- 1/8" THK. (077-B-00432)	40-75 MTR H.P.
ROUP	9	1	077-00432	SPACER- 3/8" THK. (077-B-00432)	10-30 MTR H.P.
0"	9	1	077-00434	SPACER- 3/8" THK. (077-8-00432)	40-75 MTR H.P.
	10	1	869-00119	NUT, JAMB- SELF LOCK (1"-14 UNF)	0-7.5 MTR H.P.
	10	1	869-00177	NUT, JAMB- SELF LOCK. (1-1/4"-12 UNF)	10-30 MTR H.P.
, [	10	1	869-00180	NUT, JAMB- SELF LOCK. (1-3/8"-12 UNF)	40-75 MTR H.P
	11	1	952-00132	WASHER, (2 OD, X 1.0625 ID.)	0-7.5 MTR H.P.
	11	1	952-00225	WASHER, (2.5 OD. X 1.3125 ID.)	10-30 MTR H.P.
	11	1	952-00338	WASHER, (2.75 OD. X 1.4375 ID.)	40-75 MTR H.P.

,—	. —			
12	4	952-176	CAPSCREW, HEX, HD. 1/2"-13	30-40 MTR H P.(D.P.)
	-			30 MTR H.P. (TEFC)
12	4	869-95	CAPSCREW, HEX, HD, 5/8"-11	50-75 MTR H.P. (D.P.)
	ļ			40-75 MTR H.P. (TEFC)
13	4	869-00015	NUT, HEX, 1/2*-13	30-40 MTR H.P.(D.P.)
	<b>!</b>			30 MTR H P. (TEFC)
13	4	869-00017	NUT, HEX, 5/8'-11	50-75 MTR H.P (D P)
	<b>├</b> —			40-75 MTR H.P. (TEFC)
14	4	952-00108	WASHER, 1/2"	30-40 MTR H.P.(D.P.)
	<u> </u>			30 MTR H.P. (TEFC)
14	4	952-00101	WASHER, 5/8"	50-75 MTR H.P. (D P.)
				40-75 MTR H.P. (TEFC)
15	4	952-00094	LOCKWASHER, 1/2"	30-40 MTR H.P.(D.P.)
				30 MTR H.P. (TEFC)
15	4	952-00084	LOCKWASHER, 5/8*	50-75 MTR H.P. (D.P.)
				40-75 MTR H.P. (TEFC)
16	4	869-00015	NUT, HEX, 1/2"	0-15 MTR H.P.(D.P.)
				0-10 MTR H.P. (TEFC)
16	4	869-00018	NUT, HEX. 3/4*	20-75 MTR H.P (D.P.)
				15-75 MTR H.P. (TEFC)
17	4	952-00094	LOCKWASHER, 1/2"	0-15 MTR H.P.(D.P.)
				0-10 MTR H.P (TEFC)
17	4	952-00095	LOCKWASHERS, 3/4*	20-75 MTR H.P. (D.P.)
				15-75 MTR H.P. (TEFC)
18	4	841-01049	STUD, 1/2*-13 X 2* LG.	0-15 MTR H.P.(D.P.)
_			<del></del>	0-10 MTR H.P. (TEFC)
18	4	841-00972	STUD, 3/4"-10 X 3" LG.	20-75 MTR H.P. (D.P.)
-				15-75 MTR H.P. (TEFC)
19	- 8	869-00030	NUT, HEX, 3/8"-16	
20	8	952-00093	LOCKWASHER, 3/8"	
21	8	841-01530	THRD STCK, 3/8"-16 X 3-3/4" LG. PLTD	
22	8	869-00101	NUT, COUPLING, 3/8"-16 X 1-3/4" LG	
23	- 8	952-00101	WASHER, FLAT, 3/8" SAE TYPE	<del>                                   </del>

Figure 8-14: Blower Cartridge Assembly 2 of 2

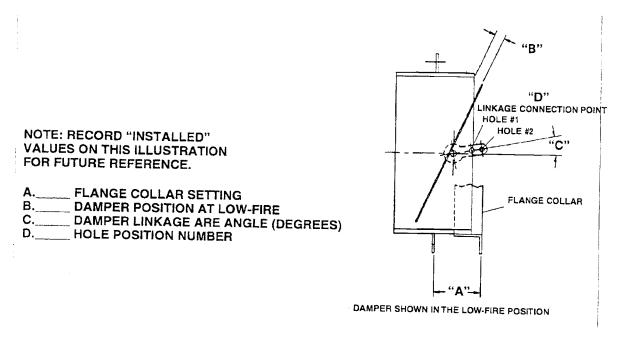


Figure 8-15: Flange Collar and Damper Settings (Top View)

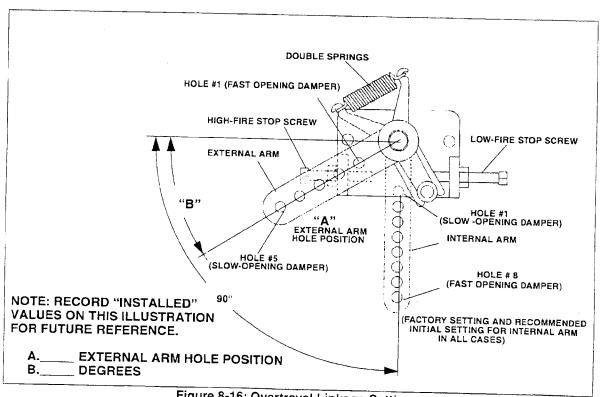


Figure 8-16: Overtravel Linkage Settings

Note: If the boiler is installed in a dusty location, check the vanes occasionally for deposits of dust or dirt. These buildups can cause a decrease in air capacity, or lead to an unbalanced condition or cause damage to the equipment.

## Q. SAFETY VALVES

The safety valve is a very important safety device and deserves attention accordingly.

Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency of testing, either by the use of the lifting lever or by raising the steam pressure, should be based on the recommendation of your boiler inspector and/or the valve manufacturer, and in accordance with sections VI and VII of the ASME Boiler and Pressure Vessel Code.

Avoid excessive operation of the safety valve; even one opening can provide a means of leakage. Safety valves should be operated only often enough to assure that they are in good working order. When a pop test is required, raise the operating pressure to the set pressure of the safety valve, allowing it to open and reseat as it would in normal service.

Do not hand operate the valve with less than 75% of the stamped set pressure exerted on the underside of the disc. When hand operating, be sure to hold the valve in an open position long enough to purge accumulated foreign material from the seat area and then allow the valve to snap shut.

Frequent usage of the safety valve will cause the seat and disc to become wire drawn or steam cut. This will cause the valve to leak and necessitate down time of the boiler for valve repair or replacement. Repair of a valve must be done only by the manufacturer or his authorized representative.

Avoid having the operating pressure too near the safety valve set pressure. A 10% differential is recommended. An even greater differential is desirable and will assure better seat tightness and valve longevity.

## R. FUEL OIL METERING VALVE, ADJUSTING AND RELIEF VALVES

In the event that a leak occurs in the packing of the metering valve, the packing nut should be snugged gradually to stop the leak (see Figure 8-17).

## **A** CAUTION

Do not over tighten the metering valve packing nut. Excessive tightening of the packing nut prevents free movement of the metering stem. Failure to follow these instructions can cause damage to the equipment.

If replacement of the metering valve packing is necessary, procure **kit P/N 880-370** and install in accordance with the following procedure.

- 1. Shut off the oil flow. Be sure no pressure shows on the gauge.
- 2. Match-mark the cam hub and drive shaft. Match marking will enable replacement of the cam in its original position and result in a minimum of cam adjustment when the burner is refired.
- 3. Clamp or hold the metering stem in the down position.
- 4. Loosen the setscrews in the cam hub and rotate, or move the cam to a position where it does not interfere with stem removal.
- 5. Withdraw the metering valve stem and spring. Do not drop or mishandle. Check for nicks or scratches. Check that the pin holding the metering portion is not protruding. Back off the packing gland.

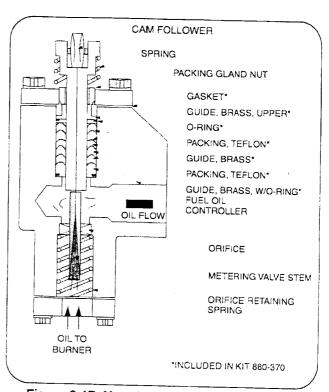


Figure 8-17: Metering Valve Packing Sequence

- Remove the capscrews holding the jack shaft support bracket so that the bracket can be moved. It may also be necessary to loosen the supporting bracket on the far end of the shaft.
- 7. Remove the existing packing and guides. Do not reuse the packing and guides.
- 8. Lightly coat the stem with the lubricant provided with the packing kit. Place the new packing, O-rings and guides onto the stem in the sequence shown in Figure 8-17. The beveled face of the guides and the tefton rings must face upward, with the exception of the upper brass guide which is faced down. Be sure that the O-rings are properly located.
- 9. Using the stem as a guide, insert the assembled packing into the cavity, then withdraw the stem.
- In the event the packing is too high, remove one teflon packing from each side of the middle brass guide as needed.

Under no circumstances eliminate the two teflon packings on only one side of the brass guide.

- Replace the gasket, put the support in place, and secure all fastenings.
- 12. Replace the metering stem and spring. Lightly lubricate the stem to facilitate insertion and easy movement. Use care when inserting so that the orifice and the stem are not damaged.
- 13. Snug the packing gland, but only sufficiently to place slight tension on the packing. The stem must move freely from the force of the spring.
- 14. Work the stem up and down several times to ensure that it is moves freely.
- 15. Depress the valve stem and replace the cam. Mate the match-marks and secure the setscrews. Be sure the eam spring is centered in the roller.
- Restore oil flow. Test fire the burner at various firing rates being certain that the metering stem freely follows the cam.
- Tighten the packing gland after a period of operation, if necessary, to maintain proper tension on the packing. Do not overtighten.

If there are indications that the oil metering valve has become clogged at its orifice, it will be necessary to disassemble the control to remove the obstruction. Clean the slotted stem of the oil metering valve with suitable solvent and blow-dry with an air line. Follow the procedure outlined above when removing or reinstalling the metering valve stem. Also check all fuel line strainers.

Should a pressure adjusting or relief valve become clogged, disassemble by releasing the locknut and backing off the screw to relieve tension on diaphragm. Remove the valve cover and the diaphragm to expose any dirt or foreign material which may have entered the valves. Clean out carefully and reassemble. It is recommended that the diaphragms be replaced annually.

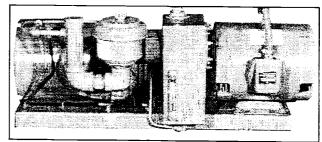


Figure 8-18: Air Compressor Module CB-LE

# S. THE AIR PUMP AND LUBRICATING SYSTEM

## Air Pump

The air pump itself requires little maintenance. However, the life of the pump is dependent upon a sufficient supply of clean cool lubricating oil. The oil level in the air-oil tank must be observed closely. Lack of oil will damage the pump making replacement necessary. Disassembly or field repairs to the pump are not recommended.

## **Lubricating Oil**

Lubricating oil must be visible in the gauge glass at all times. There is no specific level required as long as oil is visible: Do not operate if oil is not visible.

Oil with proper viscosity must be used. SAE 20 detergent is recommended, although SAE 10 detergent is also permissible.

When adding oil:

Remove the cover from the fill pipe and add oil through the conical strainer in the pipe with the unit running.

## **A** CAUTION

Oil must NEVER be added unless the pump is in operation and the strainer screen is in place. Failure to follow these instructions can cause damage to the equipment.

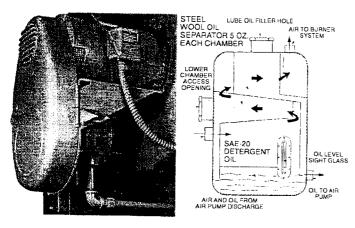


Figure 8-19: Air Oil Receiver Tank CB-LE

The oil and its container should be clean. Although there is a strainer in the lube oil line, its purpose is to remove any unwanted materials rather than to act as a filter for unclean oil.

## Lubricating Oil Strainer and Cooling Coil

Air pressure from the pump forces lubricating oil from the tank through a cooling coil to the pump. The oil lubricates the pump bearings and also provides a seal and lubrication for the pump vanes.

The cooled oil flows to the pump through the strainer in the filler pipe. It is possible to visually verify oil flow during operation by removing the filler cap and checking the flow. If necessary, the strainer may be cleaned during operation.

In the event it is necessary to clean the strainer during operation, clean it and replace immediately. It can be cleaned by immersing in solvent and blowing it dry with compressed air. Do not operate without the strainer any longer than necessary, and never add new oil unless it is in place. A spare strainer basket can be obtained, if desired, and used on a rotating basis while the other is serviced.

#### Air Cleaner

Never operate the air pump without the air cleaner in place. The cleaner itself must be periodically checked and its element flushed and cleaned semi-annually.

#### Air-Oil Tank

Pads of steel wool are used in the air to oil tank as a filtering medium to separate the lube oil from the compressed air. Figure 8-19 shows a cross-section of the tank and the location of the steel wool.

The pads play a very important role and should be replaced semi-annually. It is also important that a proper grade of steel wool be used. Only No. 3 coarse grade American steel wool or equal (CB919-124) should be used. Three pads are

required. When replacing the wool, insert two pads into the cylinder. Alternate the grain of the pads. Install the spacer with its stub end toward the opening and fit one pad over the stub. Be careful not to overly compress the wool and be sure that it is fluffed out to fill all available space. Improper packing can cause high oil consumption After the last pad is in place, slip the retainer screen onto the cylinder. Be sure to fit an O-ring gasket under the cover so that a tight seal is obtained.

Follow previous instructions for oil replacement.

## Lube Oil Cooling Coil

The fins on the tubing must be kept clean and free of any dust or dirt that would resist air flow and cause overheating. Use an air hose to blow away debris. Internal cleaning of the tubes is seldom required if a good quality lube oil is used.

## Flexible Coupling Alignment

Alignment of the pump and motor through the flexible coupling is extremely important for trouble-free operation. Check the coupling alignment semi-annually and replace the coupling insert as required. Keep the coupling guard in place.

The most commonly used tools for checking alignment are a small straightedge and a thickness gauge.

The coupling must be checked for both parallel (offset) alignment and angular (gap) alignment. Parallel misalignment exists when shaft axis are parallel but not concentric (see Figure 8-20). Angular misalignment is the reverse situation - shaft axis concentric, but not parallel.

Checking parallel alignment, both horizontal and vertical can be accomplished, by laying a straightedge across the coupling halves and checking with a thickness gauge to obtain the amount of misalignment. The check should be done on the top of the coupling and at 90 degrees. A useful hint is to hold a flashlight behind the straightedge so that any gap can readily be seen.

Shim stock of appropriate thickness and area is then used under either the feet of the pump or the motor to establish parallel alignment. A tolerance of .008" is a permissible limit.

After parallel alignment is established, check for angular alignment, which is done by checking the gap between coupling halves. The coupling should have a minimum gap of 1/16" and a maximum of 3/32".

Set the spacing between the halves at one point by using a thickness gauge and then rotate the coupling slowly to be sure that clearance at that point remains the same through 360 degrees of rotation. Adjust to obtain proper gap by loosening the hold-down bolts and shifting either the pump or the motor as required. Generally, a slight tapping on either the front or rear legs is all that is needed to obtain lateral adjustment. Rear legs may require shimming for vertical correction.

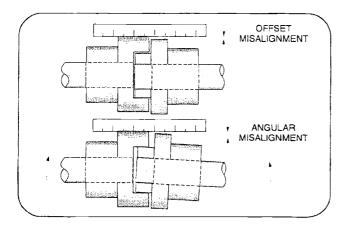


Figure 8-20: Coupling Alignment

Tighten the hold-down bolts after adjustments are made and recheck alignment.

Calipers can also be used to check angular alignment. Measure the overall distance of the outer ends of the coupling halves at 90° intervals. Shift the pump or motor, as required, so that the ends of the coupling are the same distance apart at all points. The coupling will then have proper angular alignment.

Remember that alignment in one direction may alter alignment in another. Recheck both angular and parallel alignment procedures after making any alteration.

A properly aligned coupling will last longer and will provide trouble-free mechanical operation.

## Air Compressor Replacement

Refer to Chapter 8, Figure 8-18, 19 & 20 for identification of various components and use the following procedures in replacing the pump on a CB-LE. Be sure to tag the motor leads if disconnected to simplify reconnection.

## Dismantling

- Lift out the two front cylinder pins that hold the screen, and remove the screen.
- 2. Disconnect the flared nut on tubing "A" (behind screen) and lift tubing "A" high enough to prevent drainage of lubricating oil from the tank.
- 3. Disconnect the flared nut at the orifice fitting.
- Remove the two sheet metal screws that hold the cylinder in place. One screw is located at the top rear of cylinder, the other is at the bottom front.
- 5. Remove the entire heat exchange assembly, consisting of the cylinder, the finned tubing, and the oil line "B."

- 6. Remove the fan from the air pump.
- Disconnect the flexible air line from the lube tank.
- 8. Remove the coupling guard by pushing in on both sides until it clears the clamp.
- 9. Loosen the clamp at the rear of the tank and remove the tank with copper tubing "A" attached.
- 10. Leave the rear pump bracket (coupling end) in place to aid in realignment of the replacement pump. Do this by removing the two capscrews that extend through the bracket into the pump housing. Temporarily leave the front bracket attached to the pump.
- 11. Remove screws holding the front bracket to the base and lift off the pump with its attachments. Note the location of the pipe fittings and brackets prior to removing for installation on the replacement pump. If piping is dismantled, be sure that the check valve is reinstalled so that the gate swings towards the pump.

## Reassembly

Reassembly in reverse order of disassembly. With the rear pump bracket left in place, realignment and spacing between the pump shaft and the motor shaft is greatly simplified.

There should be approximately 7/8" space between the two shafts. Place the coupling insert between the coupling halves prior to reassembly. Check that both shafts rotate freely.

Refer to the previous section on coupling alignment instructions.

If shims were used originally under either pump brackets or motor feet, be sure that they are correctly reinstalled.

When reinstalling the fan, slide the hub on the pump shaft so that it is bottomed. Tighten the setscrew and cap screws. If the fan blades were removed from the hub, be sure that the side of the blade marked "Blower" faces the hub when reassembling. When tightening the coupling halves or the fan hub, tighten the setscrews against the key first, then tighten the setscrew against the shaft. Clean or remove any dust or grime from the blades prior to reinstalling.

When replacing the retainer screen, a slight force may be required to push the cooling coil into the air cylinder so that the pins may be fitted into place.

Be sure that all piping connections are tight.

If the motor was replaced or if motor leads were disconnected, be sure that pump rotation is proper before starting operation. The air pump should rotate in a clockwise direction, as viewed from the drive shaft end.

#### General

Keep the motor and other components free from dust and dirt to prevent overheating and damage. Motor lubrication should follow manufacturer's recommendations.

## T. REFRACTORY

The boiler is shipped with completely installed refractory. The refractory consists of the rear head (Figure 8-24), the inner door, and the furnace liner (Figure 8-22). Normal maintenance requires little time and expense, and prolongs the operating life of the refractory.

Preventive maintenance through periodic inspection will keep the operator informed of the condition of the refractory, and will guard against unexpected and unwanted downtime and major repairs.

Frequent wash coating of the refractory surfaces is recommended. High-temperature-bonding, air-dry type mortar, diluted with water to the consistency of light cream, is used for wash coating. Recoating intervals will vary with operating loads and are best determined by the operator when the boiler is opened for inspection.

## **Furnace Liner**

Maintenance consists of occasional wash coating of the entire liner. Face all joints or cracks by applying high temperature bonding mortar with a trowel or fingertips. Wash coating should be done as soon as cracks are detected.

Should segments of the liner burn away or fall out, replace the entire refractory. Any refractory that may break out should be removed as soon as detected so that it will not fuse to the bottom of the furnace and obstruct the flame.

If replacement is necessary, refer to Chapter 9 and order proper replacement materials. Remove existing refractory. Thoroughly clean the furnace to remove all old refractory cement or other foreign material to ensure the new liner seats firmly against the steel. Inspect the furnace metal.

Depending upon the design pressure of the boiler, the furnace may be of the corrugated type. It is necessary to fill in the corrugation valleys under the furnace liner tile from 4 o'clock to 8 o'clock with insulating cement. The liner tile should be fitted tightly against the crown of the corrugation.

Note: The area between the burner housing and the throat tile requires a good seal. An improper or poor seal allows air leaks that can cause overheating and burning of the burner housing metal. The area should be inspected semi-annually. Contact you local Cleaver-Brooks representative for information and service

## Throat Tile and Liner Installation

The furnace lining is shown in Figure 8-21 & 22. The throat tile must be installed to maintain an approximately 12" inside diameter, and be centered in the furnace. Since the thickness of the furnace metal varies with the boiler design pressure, a shim of appropriate thickness must be used to compensate for the variance. A layer or two of insulating board or equal, or a bed of refractory material, may be used to center the ring.

The liner tile can be fitted tightly against the furnace, since the finished diameter is not critical.

It is recommended that the tile be dry-fitted, match-marked, removed, and then reinstalled with the proper amount of refractory cement. Thin joints (less than 1/16") are desirable. Generally, it will be necessary to shave a portion from one or more tiles to obtain a fit. If a fill piece is required, cut it to fit and install the piece at the bottom of the furnace. When installing the housing, or the tile against the housing, liberally coat the surface with refractory cement. Remove any cement that is squeezed out.

Allow refractory to air dry as long as possible. If immediate use is required, fire intermittently at a low rate for several hours to thoroughly dry the refractory.

For detailed information, request Bulletin C10-5921 from your local Cleaver-Brooks Representative.

#### Rear Door

The rear door is a steel shell containing horizontal baffle tiles and lined with insulation material and castable refractory (see Figure 8-24).

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble, but may be an indication of other conditions, such as:

- 1. Leaking gaskets.
- 2. Improper seal,
- Door retaining bolts insufficiently or unevenly tightened.
- 4. The air line to the rear sight tube may be blocked or loose.
- 5. Door was repainted with other than heat resistant paint.

Therefore, before assuming that the refractory requires reworking:

- 1. Check the condition of the tadpole gasket and rope seal.
- 2. Check the condition of the insulating cement protecting the tadpole gasket.
- 3. Check the horizontal baffle tile for large cracks, breaks, chipped corners, etc.
- 4. Check for cracks in the castable refractory at ends of the baffle tile.

## Chapter 8

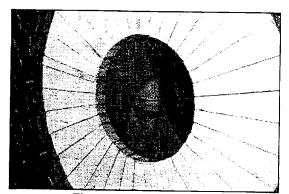


Figure 8-21: Throat Tile

## INSPECTION AND MAINTENANCE

- 5. Check the tightness of the door bolts.
- See that the air line to the sight tube is clear, and that the connections are tight. If necessary, blow the line clear with an air hose.

It is normal for refractories exposed to hot gases to develop thin "hairline" cracks. It by no means indicates improper design or workmanship. Since refractory materials expand and contract with changes in temperature, they should be expected to show minor cracks due to contraction when examined at low temperatures. Cracks to approximately 1/8" across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8" to 1/4" in width), clean and fill them with high-temperature-bonding mortar. Any gap that may show between the castable refractory and the baffle tile should be filled in a similar manner.

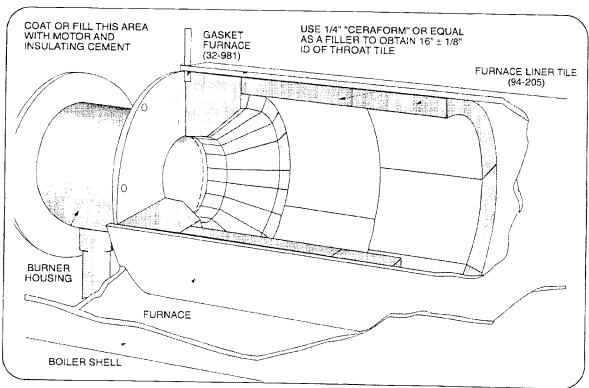


Figure 8-22: Liner Tile Furnace Liner Refractory

#### INSTALLATION NOTE:

The following procedure is typical for all standard diameter boilers with the exception of items #6,7, and 8.not used for any l.ow pressure. (plain furnace) boilers. disregard any reference to these items when working with low pressure boilers.

1. Install studs, bricking tool, cerafelt, bottom and top arch bricks as shown on **detail "A"** to check for correct fit up. If interference is present at the arch brick, measure this distance and trim inside diameter (I.D.) of all bricks.

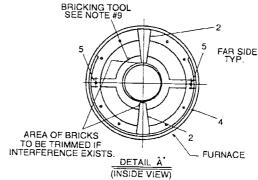
# Note: The arch bricks must be trimmed to 12" on excessive pressures to maintain brick I.D.

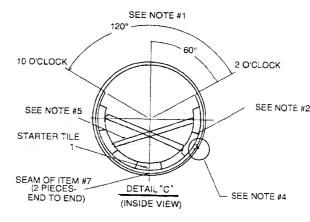
- 2. Install the bottom half of arch bricks as shown on detail "B".
- 3. Mix the vee block to a mortar-like consistency (per manufacturers instructions) and pack the front (3) valleys of the furnace corrugations with the mixture, flush with the furnace I.D. up to 3 and 9 o'clock from the centerline of the furnace. Install both pieces of cerafelt to insulate the tile from the corrugation) and begin bottom half of first row of tiles as shown on detail "c" (see note #7 an
- 4. to begin top half of arch bricks and tiles, measure off upper half of furnace arch bricks and tiles w/ templates, mark w/ chalk, and determine if a cut brick or cut tile is needed (see detail "b"). if cut brick is required, locate below2 and 10 o'clock positions (see note #4). if brick is cut, angle of cut surface should be the same as original brick.if cut brick or tile measures less than 1/2 full width, cut two (2) pieces (see note #1).
- 5. install bricking tool as shown on detail "a" and continue installing upper half by alternating one (1) arch brick and one (1) corresponding tile behind brick typical (see notes #5, 6, and 9).
- 6. for the last two (2) rows of tiles, pack all remaining valleys of furnace corrugations (measure 36" from inside surface of arch bricks) w/ vee block mixture flush w/ furnace i.d. up to 3 and 9 o'clock centerline of furnace.

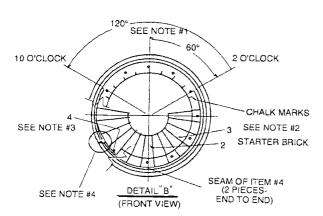
- 7. install both pieces of item #8 cerafelt and continue laying furnace tiles to complete the last two (2) rows (see note #7).
- 8. after joint cement hardens (2 hours approx.), remove bricking tool, wooden tile supports, and discard cerafelt shims.

#### NOTES:

- 1. no cerafelt, cut bricks, or cut tiles to be installed in upper 120 quadrant of furnace, as shown on details "b" and "c".
- 2. pack all bricks and tiles tightly w/ mallet and remove excess cement 1/16" typical joint/ 1/8" max.
- 3. no cement applied between cerafelt and bricks, tiles, or furnace.only applied between bricks and tiles.
- 4. do not cover furnace weld seam w/ cerafelt, cut and space to suit as shown on details "b" and "c".5, support upper tiles w/ wooden boards to suit @ assembly, two (2) boards per tile as shown on detail "c"-for 78" dia. usc 3/4" x 1-1/2" x 28" lg, approximate.
- 6. to insure tight fit and maximum i.d. of arch bricks, cut a 3" sq. piece of scrap cerafelt and use as a shim between bricking tool o.d. and i.d. of upper half of bricks typical (if necessary).
- 7. stagger cemented joints (seams) between all arch bricks and tiles.
- 8. after each half course of bricks or tiles is installed, clean up excessive cement and fill open joint areas where necessary.
- 9. for 78" dia. boiler use bricking tool #98-d-280 and fasten w/ two (2) 1/2"-13 nuts.







## Chapter 8

After opening the rear door, clean the flange with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Clean the mating surfaces of the baffle tile and the boiler shell. Remove all dried sealing material. Wash-coat the lower half of the rear door refractory prior to closing.

The upper half of the door contains a lightweight insulating material, similar to that used in the inner door. A thin wash-coat mixture, applied gently with a brush, is helpful in maintaining a hard surface.

If the baffle tile or the refractory require replacement, contact your local Cleaver-Brooks authorized representative.

#### Front Inner Door

The front inner door is lined with a lightweight castable insulation material. Thin "hairline" cracks may develop after a period of time. However, the cracks will generally close due to expansion when the boiler is fired.

A thin wash-coat mixture, applied gently with a brush, is helpful in maintaining a hard surface.

Minor repairs can be accomplished by enlarging or cutting out affected areas, being certain that they are clean, and then patching as required. Should the entire insulation require replacement, remove existing material and clean to bare metal. Inspect the retaining pins and replace if necessary. Reinforcing wire, suitably attached, may also be used. The recommended insulation is "Vee Block Mix" and is available in 50 lb bags (Cleaver-Brooks P/N 872-162).

Mix the material with water to a troweling consistency. Mixing should be completely uniform with no portion either wetter or drier than another. Trowel the mixture into any areas that are being patched. If replacing complete insulation, begin at the bottom of the door and apply the mixture to a thickness equal to the protecting shroud. With a trowel, apply horizontally back and forth across the door in layers until the required thickness is reached.

Allow to air-dry as long as possible. If immediate use of the boiler is required, fire as slowly as possible to avoid rapid drying of the material.

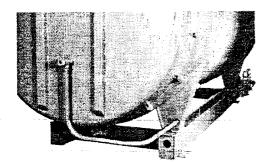


Figure 8-23: Rear Door with Site Glass Cooling Tube

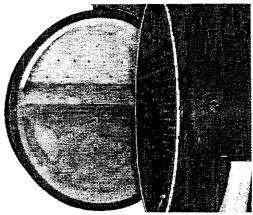


Figure 8-24: Rear Door Open

# U. OPENING AND CLOSING REAR DOOR

A good scal between the rear door and the pressure vessel is necessary to prevent leakage of combustion gases, loss of heat, and to aid in obtaining operating efficiency. Leaks can also cause hot spots that can lead to premature refractory failure and/or damage to the door metal.

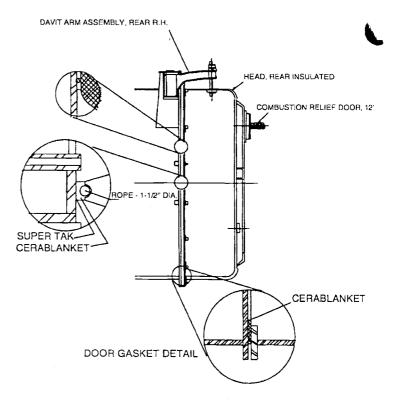


Figure 8-25: Baffle Construction

When opening the door, either for routine maintenance or for an annual inspection, do not do so when the boiler or the door is hot. The refractory will hold its temperature for some time and exposure to ambient temperature or rapid cooling may cause refractory cracking and/or harm to the boiler and door metal.



Be certain that the davit arm is under tension before opening. Failure to follow these instructions can result in serious personal injury or death.

Before loosening the door bolts, tighten the nut on the davit stud to ensure tension on the davit arm. Putting the davit arm under tension will help eliminate sagging, and will facilitate opening and closing.

The opened door should be supported by blocking or jacking to eliminate possible deformation of the door.

Prior to closing, check all gaskets and sealing surfaces. If the door gasket is hard or brittle, it should be replaced. The fiberglass ropes used for the baffle seal and for the door gasket seal should not be reused. The door flange and the tube sheet area of the baffle seal should be clean and free of old sealing material, scale, etc. Be sure that all of the gasket retaining fasteners are in place.

Remove the old rope and insulating cement from the baffle tile or refractory. Be careful not to chip or crack the refractory. The rope is placed in the groove of the monolithic design and on top of the lip of the tile baffle type construction.

Attach a new length of 1-1/4" diameter fiberglass rope (P/N 853-982) to the baffle. Be certain that it is properly positioned and use a rapid setting adhesive (P/N 872-481) to hold it in place.

Note: A boiler built for high pressure design, such as 150 psi or higher steam or for 60 psi or higher hot water, is constructed with a flanged tube sheet that fits inside the boiler shell and door flange.

The area between the curved portion of the sheet and the flange is packed with fiberglass rope and covered with cement to fill the void and to provide a smooth sealing area.

Replacement is not normally necessary, but, if it is, completely remove the old material. Firmly caulk a layer of 1/2" diameter rope (P/N 853-996) into the area. Tamp a second layer of 1" diameter rope (P/N 853-999) over the first layer. Apply a coating of insulating cement pulp (P/N 872-26) over the ropes to form a smooth surface. Allow the cement pulp to harden before closing the door.

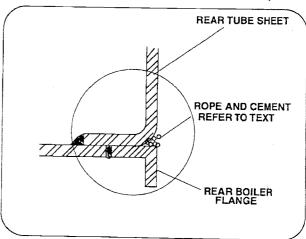


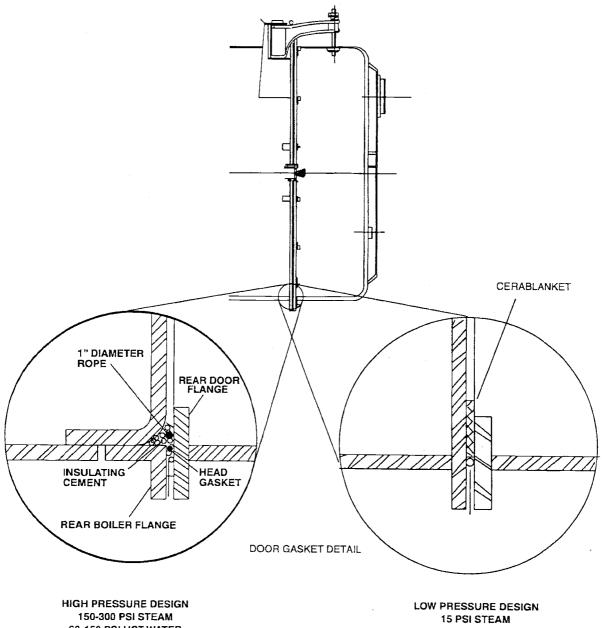
Figure 8-26: Rear Flange, Power Boiler

## Closing and Sealing

Coat the door gasket with an oil and graphite mixture. Apply a small amount of a pulp mixture, consisting of P/N 872-26 cement and water around the inner circumference of the gasket. Press rope into this area. Use 1/2" diameter rope (P/N 853-996) for a boiler of low pressure design. Use 1" diameter rope (P/N 853-999) for a high pressure boiler.

After the rope is installed, the entire rope and gasket area, and the baffle area, should be liberally coated with the pulp mixture. When the door is closed, the pulp will compress to protect the tadpole gasket and form a seal between the refractory surface and the tube sheet.

Door bolts should be run in snug and tightened evenly to avoid cocking the door and damaging the gasket. Start tightening at top center and alternate between the top and bottom bolts until both are tight. Do not overtighten. Tighten alternate bolts until the door is secured and gas tight. After the boiler is back in operation, retighten the bolts to compensate for any expansion. Loosen the nut on the davit stud to release tension from the davit arm.



60-150 PSI HOT WATER

30 PSI HOT WATER

Figure 8-27: Rear Door Sealing

## V. LUBRICATION

## **Electric Motors**

Manufacturers of electric motors vary in their specifications for lubrication and care of motor bearings; their specific recommendations should be followed.

Ball-bearing-equipped motors are pre-lubricated. The length of time a bearing can run without having grease added will depend upon many factors, including the rating of the motor, type of motor enclosure, duty, atmospheric conditions, humidity, and ambient temperatures.

Complete renewal of grease, when necessary, can be accomplished by forcing out the old grease with the new grease. Thoroughly wipe those portions of the housing around the filler and drain plugs (above and below bearings). Remove the drain plug (bottom) and free the drain hole of any hardened grease which may have accumulated. With the motor not running, add new grease through the filler hole until clear grease starts to come out of the drain hole. Before replacing the drain plug, run the motor for 10 to 20 minutes

to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

The lubricant used should be clean and equal to one of the good commercial grades of grease locally available. Some lubricants that are distributed nationally are:

- Gulf Oil Precision Grease No. 2
- · Humble Oil Andok B
- · Texaco Multifak No. 2
- Phillips 1B + RB No.2
- Fiske Bros. Ball Bearing Lubricant
- Standard/Mobil Mobilux No. 2

## **Control Linkage**

Apply a non-gumming, dripless, high temperature lubricant, such as graphite or a silicone derivative to all pivot points and moving parts. Work lubricant in well and wipe excess. Repeat application at required intervals to maintain freedom of motion of parts.

## Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

## **IFGR Lubrication**

Motors should be lightly lubricated at startup, using the grease specified below or equivalent. Lubricate the motor as follows:

## **A**WARNING

Disconnect and lock out electrical power to the boiler before lubricating the fan motor. Failure to follow these instructions can cause injury or death.

- 1. Disconnect and lock out electrical power to the boiler.
- 2. Wipe clean all grease fittings (fill and drain fittings).
- 3. Remove the fill and drain plugs from the motor end cap.
- 4. Free the drain hole of any hard grease. (Use a piece of wire, if necessary.)
- 5. Add grease using a low-pressure grease gun.

Note: The amount and type of grease is very important. Only enough grease should be added to replace the grease used by the bearing. Either too much or too little grease can be harmful. The grease cavity should be filled 1/3 to 1/2 full, using Chevron SRI 2 grease or equivalent. Shell Dolium R is a suitable substitute lubricant.

Daily	Check visually for free movement of IFGR linkage.
Quarterly	Manually check for free movement of IFGR linkage.
	<ul> <li>Inspect and clean IFGR damper (oil-fueled system).</li> <li>Inspect and clean fan and burner (oil-fueled system).</li> <li>Grease fan motor.</li> </ul>
Semi-Annual	inspect and clean IFGR damper (gas-fueled system).
	<ul> <li>Inspect and clean fan and burner (gas-fueled system).</li> </ul>
	<ul> <li>Open motor/fan cassette to check for free movement of IFGR linkage and damper assembly.</li> </ul>
Annual	Inspect fan impeller.
	Check emissions.
	Change inlet gasket.

- 6. With the fill and drain plugs still removed, apply electric power to the boiler, start the motor, and let it run for approximately 30 minutes.
- 7. Turn boiler off.

## **WARNING**

Disconnect and lock out electrical power to the boiler before lubricating the fan motor. Failure to follow these instructions can cause injury or death.

- 8. Disconnect and lock out electrical power to the boiler.
- Wipe excess grease from the motor, and install the fill and drain plugs. Motor is ready for operation.
- 10. Reconnect electrical power.

## W. OIL HEATERS - ELECTRIC, STEAM, HOT WATER

An annual maintenance of the heaters consists primarily of removing the heating element from the shell and scraping any accumulation of carbonized oil or sludge deposits that may have collected on the heat exchanging surfaces.

Before breaking any of the electrical connections to the electric heating elements, mark all wires and terminals to assure rapid and correct replacement of wires.

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Finish the cleaning process with a cleaning solvent to cut all hardened deposits from the heater element. Because of the insulating effect of carbon and sludge, periodic cleaning is necessary to prevent overheating of the elements. If operation of the heater becomes sluggish, examine the elements at once and clean as required.

Inspect the shell or tank each time the heater is removed. Flush all accumulated sludge and sediment from the tank before reinstalling the heater.

The condensate from steam oil heaters must be safely discharged to waste. The waste should be checked periodically for any traces of oil that would indicate leaking tubes within the heater.

The hot water oil heater (Figure 8-30) contains a heat transfer solution. Oil flows through an inner tube while boiler water surrounds the outer tube. The space between the two tubes is filled with the heat transfer solution and is connected to an expansion chamber on the rear of the heater. A visual indicator on the chamber reveals the presence of any oil if an oil leak occurs.

A 50/50 solution of permanent antifreeze and water is generally used as the heat transfer solution. If there is no danger of freezing, plain water may be used as a replenishment if necessary to refill.

Evidence of oil in either the steam heater condensate or in the water heater indicator demands prompt repairs.

## X. COMBUSTION

The frequency of burner adjustments depends upon several factor, including; type of burner, type of fuel, load conditions, ambient temperature, climatic variables, and general maintenance practices.

The air-fuel ratio should be checked monthly in order to alert the operator to losses in efficiency, which do not produce visible flame change. Any time maintenance is performed on the burner linkage, the air-fuel ratio should be checked. Readjustment of the burner may be required due to variations in fuel composition. A combustion analyzer should be used to adjust air-fuel ratio for maximum operating efficiency. If your burner requires adjustments, contact your local Cleaver-Brooks authorized representative for assistance.

#### Y. AIR PUMP BELT

The V-belt driving the air pump requires no servicing and no preservatives or dressing compounds should be used. Belts normally stretch with use and proper tension should be maintained. Do not apply excessive tension. The air pump can

be moved the small distance necessary for belt adjustment without any change of piping.

On a combination fired unit it is an acceptable practice to remove the belt when gas is being used for extended periods. It is not absolutely necessary to do this, however pump and belt life will be extended if the belt is removed.

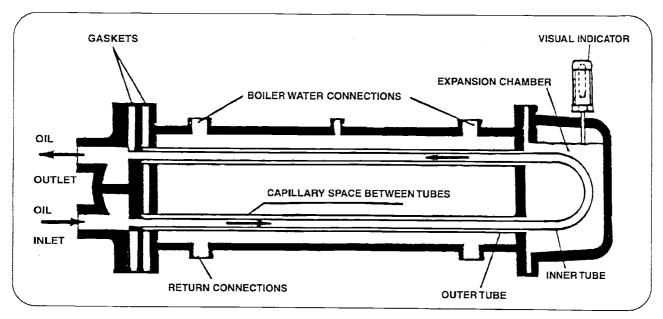


Figure 8-28: Circuit Layout of Hot Water Oil Heater

Windbox Temperature (Typical) - Natural Gas		
60 PPM	130°-140° F	
30 PPM	160°-175° F	
25 PPM	185°-195° F	
20 PPM	195°-210° F	

DAILY	MONTHLY	SEMI- ANNUALLY	ANNUALY
Check water level	Inspect burner	Clean low water cutoff	Clean fireside surfaces
Check combustion visually	<ul> <li>Inspect for flue gas leak</li> </ul>	Clean oil pump strainer, filter	Clean breeching
Blow down boiler	<ul> <li>Inspect for hot spots</li> </ul>	Clean air cleaner and air/oil separator	Inspect waterside surfaces
Blow down water column	Check cams	• Inspect refractory	Check operation of safety valves
Record feedwater pressure/temperature	Check for tight closing of fuel valve	Remove and clean oil preheater	
Record flue gas	Check fuel and air linkage	Check air pump coupling alignment	
Record oil pressure and	Check indicating lights and alarms	Inspect / repair burner housing to refractory seal	
temperature	Check operating and limit controls	remactory seal	
Record gas pressure	Check safety and interlock		
<ul> <li>Treat water according to the established program</li> </ul>	controls		
Record atomizing air pressure	<ul> <li>Check for leaks, noise, vibration, unusual conditions, etc.</li> </ul>		
	Check low water cutoff operation		

Figure 8-29: Recommended Boiler Inspection Schedule

# Notes

# CHAPTER 9 CUSTOMER SERVICE AND PARTS

FURNISH COMPLETE INFORMATION WHEN ORDERING PARTS - When ordering parts or spares, give the description and the quantity of parts desired, together with the complete nameplate data, including all electrical requirements.

WHERE TO ORDER PARTS - Repair and replacement parts should be ordered from your local Cleaver-Brooks authorized representative.

CB BOILER HORSEPOWER	SHELL DIAMETER
400 - 800	96"
250 - 350	78"
125 - 200	60"
50 - 100	48"
15 - 100	36"

Cleaver Brooks
CB PACKAGED BOILER
MODEL SERIAL NO.
MAX PRESSURE PSI DATE
INPUT BYU/HR GAS GPH OIL
ELECTRICAL REQUIREMENTS
MAIN POWER SUPPLY
VOLTS PH HE AMP
MINIMUM CIRCUIT AMPACITY AMP
MAX. RATING OF CIRCUIT PROTECTION AMP
BLOWER MOTOR HP
AIR COMPRESSOR MOTOR HP
OIL HEATER KW
CONTROL CIRCUIT
OIL PUMP MOTOR
VOLTS PH HZ AMP
CLEASTR BRIGHT DIVISION ADDA CHEM INC 118 208 MILWAUKLE WICCINNS Q U.S.A

Contact your local Cleaver-Brooks authorized representative for prompt supply of replacement parts.

## **Table Of Contents**

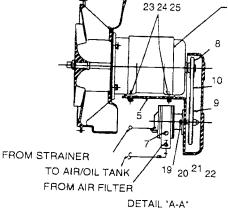
Air Compressor and Piping	9-3, 9-4, 9-5
Burner Housing Support & Front Head PLT STD & HTD	9-6. 9-7
Control Panel	9-8, 9-9
Entrance Box	9-10. 9-11
Front Head (Electrical) Standard CB	9-12, 9-13
Front Head (Electrical) CB-LE	9-14, 9-15
Front Davit Standard CB	9-16. 9-17
Front Davit CB-LE	9-18, 9-19
Front Head Insulation	9-20
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Gas Train Equipment	9-23. 9-24
Light Oil Piping Front Head	9-25, 9-26, 9-27
Heavy Oil Piping9-28, 9-29, 9-30, 9-31, 9-3	2, 9-33, 9-34, 9-
IFGR	9-36, 9-37, 9-38
Pressure Controls	9-39
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W.Cmain & Aux. CB	9-41 9-42
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Rear Head Sealing & Davit	9-44
Throat Tile And Furnace Liner	9-45 46

## Notes

USED ON

FUELS 100, 101,

200, 400, & 600





QTY

1

1

PART NO.

530-B-97

530-B-96

ITEM

27

28

29

30

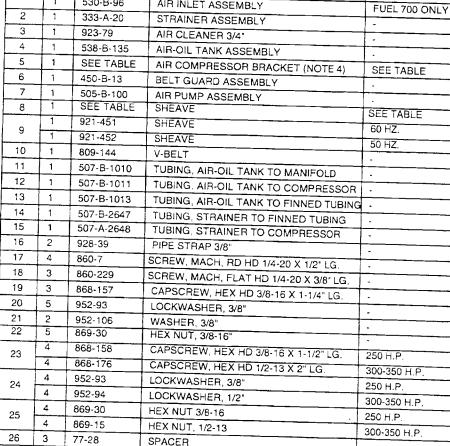
31

1

6

6

1



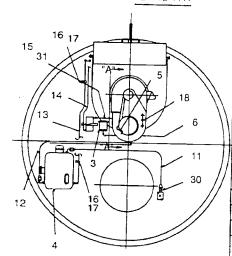
PIPE STRAP, 2"

LOCKWASHER, 1/4"

AIR INLET ASSEMBLY

AIR INLET ASSEMBLY

DESCRIPTION



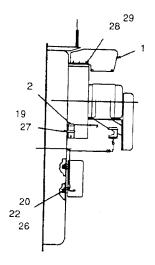


			TABLE ITEN	MS 5 & 8	
		60	HZ.	Т	HZ.
	H.P.	ITEM 5	ITEM 8	ITEM 5	ITEM 8
СВ	250	8-C-2323	921-595	8-C-2326	921-461
&	300	8-C-2326	921-584	8-C-2326	921-461
CBW	350	8-C-2326	921-584	8-C-2327	921-461
CBW	400	8-C-2326	921-584	8-C-2327	921-461

CAPSCREW, HEX HD 1/4-20 X 3/4" LG.

FLARED NUT, 45 X 1/4" ODC

FLARED ADAPTER, 3/4" NPT X 3/4" ODC

928-49

952-92

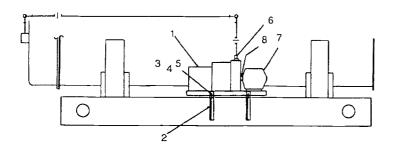
845-39

845-8

868-136

-

#### BOLT HEAD ON TOP



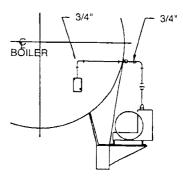
SIDE ELEVATION 78 \*

	BILL OF MATERIAL FOR 60° & 78" DIA.				
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	
1	1	505-113	COMPRESSOR ASSEMBLY	-	
2	2	8-A-2345	BRACKET	-	
3	4	868-104	CAPSCREW, HEX. HD. 5/16"-18 X 1" LG.		
4	4	952-114	LOCKWASHER, 5/16"	-	
5	4	952-133	WASHER, 5/16"	-	
6	1	847-469	BUSHING, RED. 1" X 3/4"	78"	
7	1	SEE TABLE	MOTOR		
8	1	SEE TABLE	COUPLING, HALF	-	

	TABLE ITEMS 11 & 12				
ITEM	200-460V (60 HZ)	600V (60 HZ)	200-380V (50 HZ)		
7	894-3431	894-3432	894-2291		
8	819-158	819-158	819-150		

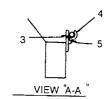
## NOTES:

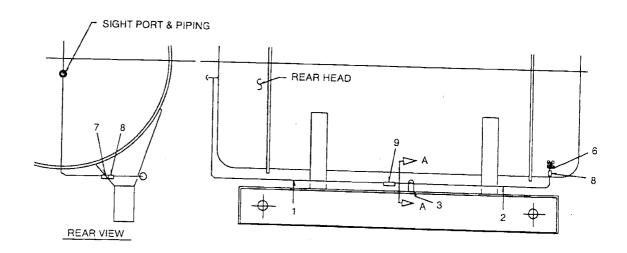
- 1. UNLESS OTHERWISE NOTED, ALL PIPE TO BE SCH. 40 ASTM A120 WELDED BLACK STL. AND ALL FITTINGS TO BE 150# M.I..
- 2. ALL DIMENSIONS ARE APPROXIMATE.



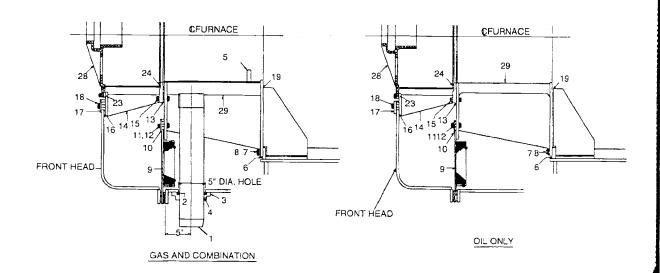
FRONT ELEVATION 78 "

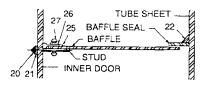
ITEM	QT	PART NO.	DESCRIPTION
1	1	827-8	BULK CONDUIT, 1/2" THINWALL EMT. X "B" LG. APPROX.
2	1	827-8	BULK CONDUIT, 1/2" THINWALL EMT. X "A" LG. APPROX.
3	1	8-A-2833	BRACKET
4	1	928-33	PIPE STRAP, 1/2" CONDUIT
5	1	868-136	CAPSREW, HEX HD: 1/4"-20 X 3/4" LG.
6	1	859-118	ELBOW, STREET, 1/2" X 45 (SEE NOTE 3)
7	1	848-141	COUPLING, 1/2" CONDUIT
8	2	848-325	CONNECTOR, STRAIGHT, 1/2" EMT. CONDUIT
9	1	848-398	COUPLING, UNION, 1/2" EMT. CONDUIT





## AIR LINE PIPING





BAFFLE ATTACHMENT

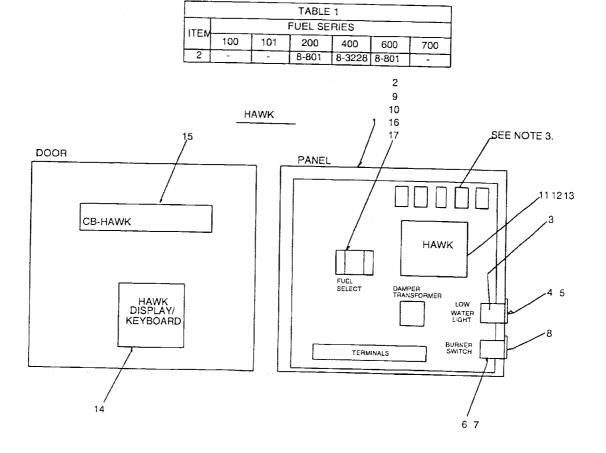
STAN	DARD 78" CB	BOILER TABL	E ITEM 28	
H.P.	100	101-200	400-600	700
250	429-D-1266	429-D-1270	429-819	429-D-1273
300	429-D-1266	429-1271	429-819	429-D-1273
350	429-1268	429-1272	429-820	429-1274

78" "LE" BOILER TABLE ITEM 28					
H.P.	100	101-200	400-600	700	
250		**	429-1389	429-1387	
300			429-1389	429-1387	
250 & 300 60 PPM ONLY	429-1356	429-1358			
350			429-1390	429-1388	
350 60 PPM 250-350 30,25,20 PPM	429-1357	429-1359			

			BILL OF MATERIAL FOR 78" CB, CBW, & "LE" BOILERS		<del></del> -		
ITEM	QTY	PART No.	DESCRIPTION	HP	FUEL	USED ON	OPTION CODE
1	_1	57-1125	BULK PIPE - 4" x 19-1/4" T.B.E.		GAS/COMB		A8
2	1	<u>853</u> -348	BULK PACKING - 1/4" DIA. x 12"	-	GAS/COMB	-	A8
3	1	65-B-177	RETAINER - GASKET	-	GAS/COMB		A8
4	3	860-15	SET SCREW - SOCKET HEAD	-	GAS/COMB	-	<del> </del>
5	. 1	146-334	SPUD KIT AND PATTERN				
6	1	656-7967	INSTALLATION-GASKET (656D7965)	<del> </del>	<del>  -</del>	<u> </u>	
7	20	952-286	WASHER - 1/2"		<del> </del>	<del></del>	
8	20	869-29	NUT HEX 1/2-13	<del>  .                                     </del>	<del></del>		
	1	465-B-635	INSULATED FRONT HEAD PLATE, LH SWING		<del></del>	STD. CB ONLY	CR
9	1	465-B-138	INSULATED FRONT HEAD PLATE, RH SWING	<del>-</del>	<del></del>	STD. CB ONLY	CR
	1	15-B-121	FLANGE RING				
10	8		CLAMPS		-	ALL EXCEPT 78"LE	A2
11	8	296-A-19	WASHER - 3/8" BRASS	· ·	<del> </del>	78" LE	A2
12	- 8	952-106	NUT HEX 3/8-16 BRASS	-	-	-	
13	2	869-37		-	-		
14	-1	32-A-928	GASKET - BURNER HOUSING SUPPORT	-	-		A2
15	8	85-C-444	SUPPORT - BURNER HOUSING	•	-	•	A2
16	1	869-29	NUT HEX 1/2-13 BRASS	-	-	-	
L		853-3	SET-PACKING - 3/8" x 71-1/2" LG.	•	-		A2
17 18	- 8	15-B-39	FLANGE RING	•	-	-	A2
19		869-15	NUT HEX 1/2-13	-	-		<b>-</b>
20	10#	872-390	CEMENT - REFRACTORY	-	-		A3
1 1	3	869-37	NUT HEX 3/8" BRASS	-	-	ALL EXCEPT "LE"	
21	6	952-326	WASHER - 3/8" FLAT BRASS	-	-	ALL EXCEPT "LE"	
22	50z.	872-558	THERMO SILICATE CEMENT	-	-	-	
23	1	32-A-927	GASKET - BURNER PLATE	-	<del></del>	STANDARD	
	2	32-A-927	GASKET - BURNER PLATE	-	-	HIGH TURN	
24	1 *	853-1017	GASKET-1/8" x 1" x 42-13/16" SILICON	-	-	DOWN ONLY	A8
25	1 *	853-394	GASKET 2" x 78"		<del></del>	ALL EXCEPT "LE"	A2
L	6.5FT	971-291	STRIP - PERFORATED	-	-	ALL EXCEPT "LE"	A2
1	24	841-A-551	RIVET		<del> </del>	ALL EXCEPT "LE"	
28	1	SEE TABLE	BURNER DRAWER		-	-	A.C.
	7	40-C-402	HOUSING - BURNER	250-350	NATURAL	STANDARD, GAS,	A5
	1	40-C-446	HOUSING - BURNER	250-350	PROPANE	& COMBINATION	A8,B6
29	1	40-C-396	HOUSING - BURNER	250-350	OIL	STANDARD & HIGH TURN DOWN, OIL	PG A8
	1	40-C-565	HOUSING - BURNER		-	HIGH TURN DOWN, GAS, & COMBINATION	A8,PG ,BG

<sup>\*</sup> SOLD BY THE FOOT

		CONTR	OL CABINET (HAWK)		
ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPTION
1	1	283-B-2978	CONTROL CABINET		C3
2	1	SEE TABLE 1	SWITCH BRACKET		C3
3	1	881-231	PILOT LIGHT	<del>-</del>	C3
4	1	881-232	LENS, RED		C3
5	1	118-644	NAMEPLATE, LOW WATER	•	C3
6	1	836-620	SWITCH, OPERATOR		C3
7	1	836-623	SWITCH CONTACT BLOCK	-	— C3
8	1	118-1382	NAMEPLATE, BURNER OFF-ON		C3
9	1	836-261	FUEL SELECTOR SWITCH	FUEL 200,400	C3
10	1	118-196	NAMEPLATE, GAS-OIL	FUEL 200,400	C3
11	1	833-2415	HAWK CHASSIS		C3
12	1	833-2421	HAWK AMPLIFIER	-	C3
13	1	833-2418	HAWK PROGRAM MODULE	_	C3
14	1	833-2419	HAWK KEYBOARD/DISPLAY	<del></del> _	<del></del>
15	1	118-2462	LABEL, CB HAWK		C3
16	1	836-210	OIL HEATER SWITCH	FUEL 400,600	<del> </del> -
17	1	118-204	NAMEPLATE, OIL HEATER	FUEL 400,600	C3



	<del></del>	TABLE 1 - IT	EM 8		
ВМ НР			VOLTAGE		
DIVIDE	200-208V	220-240V	346-416V	440-480V	575-600V
2	833-1884	833-1884	833-1884	833-1884	833-1884
3	833-1884	833-1884	833-1884	833-1884	833-1884
5	833-1885	833-1885	833-1884	833-1884	833-1884
7-1/2	833-1885	833-1885	833-1885	833-1885	833-1885
10	833-1886	833-1886	833-1885	833-1885	833-1885
15	833-1197	833-1886	833-1886	833-1886	833-1886
50	833-1197	833-1197	833-1886	833-1886	833-1886
30	NOTE 1	833-1197	833-1197	833-1197	833-1197
40	NOTE 1	NOTE 1	833-1197	833-1197	833-1197
50	NOTE 1	NOTE 1	833-1197	833-1197	833-1197
60	NOTE 1	NOTE 1	NOTE 1	NOTE 1	NOTE 1

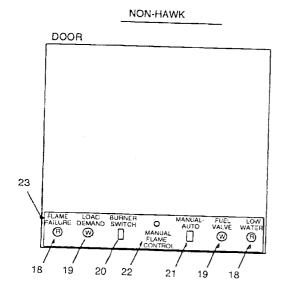
			TABLE	2		
ITEM			FUEL SE	ERIES		
	100	101	200	400	600	700
	<u> </u>	<u> </u>	8-801	8-3228	8-801	<u> </u>

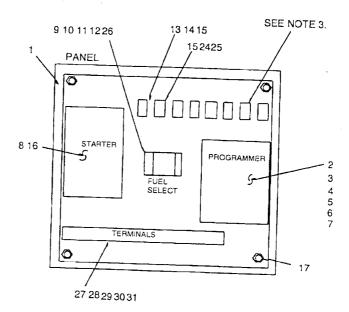
CONTROL CABINET (NON-HAWK)							
ITEM	ΩΤΥ	PART NO.	DESCRIPTION	USED ON	OPTION		
1	1	119-405	CONTROL CABINET (W/SUB BASE)	<del>                                      </del>	D3		
2	_1		PROGRAMMER-BASE	+	1 03		
3	1	]	PROGRAMMER-DISPLAY	<del></del>	1		
_4_	_1_	SEE TABLE 3	PROGRAMMER-CHASSIS	<del> </del>	SEE		
5	1	JOCE IMPLE 3	PROGRAMMER-AMPLIFIER	<del> </del>	TABL		
6	1	]	PROGRAMMER-MODULE	+	3		
7	1	<del></del>	PROGRAMMER-FLAME DETECTOR	<del> </del>	1		
8	1	SEE TABLE 1	STARTER (SEE NOTE 2)	T	D3		
9	1	836-746	SWITCH,GAS-OIL	FUEL 200,400			
10	1	118-196	NAMEPLATE, GAS-OIL	FUEL 200,400	D3		
11	-	SEE TABLE 2	BRACKET	1 022 200,400	D3		
12	1	836-210	SWITCH,OIL HEATER	FUEL 400.600			
13	1	833-2261	RELAY	FUEL 200,400	D3		
14	_	833-2263	BASE	FUEL 200,400	D3		
15	2	841-1483	SCREW, SELF-TAPPING	WITH ITEM 14,25	D3		
16	3	841-801	SCREW, SELF-TAPPING	WITH ITEM 14,25			
17	4	841-89	NUT, SELF-LOCKING	AMINITEM 8			
18	2	881-225	LIGHT ASSEMBLY, RED LENS	<del>                                     </del>	<u> </u>		
19	2	881-226	LIGHT ASSEMBLY, WHITE LENS	<del>                                     </del>	C4		
20	1	836-210	SWITCH, BURNER	ļ -	C4		
21		B36-211	SWITCH, MANUAL - AUTO	<u>├</u>	C4		
22	1	836-209	SWITCH, MANUAL FLAME CONTROL	<del>                                     </del>	C4		
23	1	118-1689	NAMEPLATE	<u> </u>	C4		
24	, ]	833-2261	RELAY (AIR PURGE)	<del>                                     </del>	C4		
25	1	833-2263	BASE (AIR PURGE)	FUEL 400,600	D3		
26	1	118-204	NAMEPLATE-OIL HEATER	FUEL 400,600	DЗ		
27	38	832-749	TERMINALLUG	FUEL 400,600	D3		
28	1	832-751	END BARRIER	<u> </u>			
29	2		RETAINING CLIP				
30	1		CHANNEL		· .		
31	7		MARKING STRIP	· _			

					_			
			TAB	LE 3				
FLAME	ITEM	_ 2	3	4	5	6	7	
SAFEGARD	,	BASE	DISPLAY		AMP. (IR)	MODULE	FD (IR)	
CB780	(D4)	833-2725	833-2727	833-2718	833-2722	833-2730	812 1742	
CB100E	(D0)		833-2714		833-2584	833-2583		
E110	(D5)	833-2214	833-2713			833-2383		

- NOTES: 1. STARTER IS IN OWN ENCL. MOUNTED ON THE FRONT HEAD.
  SEE REFERENCE DWG. 146-C-121.
  2. OVERLOADS ARE TO BE SUPPLIED BASED ON MOTOR NAMEPLATE
  - 2. OVERLOADS ARE TO BE SUPPLIED BASED ON MOTOR NAMEPLATE AMP. RATING.

    3. FOR NON-HAWK PANEL, MAXIMUM QUANTITY OF RELAYS, TIMERS, OR COMBINATION OF BOTH IS 8. FOR HAWK PANEL THE MAXIMUM QUANTITY IS 5.





#### MOTOR, OIL HEATER, & CCT FUSE SIZING

#### RECOMMENDED MAXIMUM "FUSETRON" FUSE SIZES

#### FUSE PART NO.S

ELECTRICAL LOAD	SINGLE PHA	SE 50/60 HERT.	Z	THRE	E PHASE 50/60	HERTZ	_	AMP	5.150.111.501	
ELLO TRIONE COND	110-120 V	220-240 V	200-208 V	220-240 V	346-416 V	440-480 V	550-660 V	RATING	BUSSMAN FAN	BUSSMAN FRS
1/4 HP MOTOR	FRN-8	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10		FRS-1	FRS-8/10	.8		832-491
1/3 HP MOTOR	FRN-9	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10	-	FRS-1	FRS-8/10	1 1	832-1211	832-141
1/2 HP MOTOR	FRN-12	FRN-6-1/4	FRN-2-8/10	FRN-2-8/10	FRS-1-8/10	FRS-1-4/10	FRS-1	1 1.4		832-492
3/4 HP MOTOR	FRN-17-1/2	FRN-9	FRN-4-1/2	FRN-4-1/2	FRS-2-1/4	FRS-1-8/10	FRS-1-4/10	1.8	832-480	832-493
1 HP MOTOR	FRN-20	FRN-10	FRN-5	FRN-5	FRS-3-2/10	FRS-2-1/4	FRS-1-8/10	2		832-497
1 1/2 HP MOTOR	FRN-25	FRN-12	FRN-7	FRN-7	FRS-4	FRS-3-2/10	FRS-2-1/2	2.25	832-279	832-494
2 HP MOTOR	FRN-30	FRN-15	FRN-9	FRN-9	FRS-5-6/10	FRS-4-1/2	FRS-3-1/2	2.5	832-482	832-495
3 HP MOTOR	FRN-40	FRN-20	FRN-12	FRN-12	FRS-8	FRS-6-1/4	FRS-5	28	832-460	832-416
5 HP MOTOR		FRN-35	FRN-20	FRN-20	FRS-12	FRS-10	FRS-8	3.2	832-483	832-142
7-1/2 HP MOTOR		FRN-50	FRN-30	FRN-30	FRS-17-1/2	FRS-15	FRS-12	3.5	832-484	832-433
10 HP MOTOR		FRN-60	FRN-40	FRN-35	FRS-20	FRS-17-1/2	FRS-15	4	832-662	832-441
15 HP MOTOR			FRN-60	FRN-50	FRS-30	FRS-25	FRS-20	4.25	832-152	832-496
20 HP MOTOR		1	FRN-70	FRN-70	FRS-40	FRS-35	FRS-25	4.5	832-299	832-442
25 HP MOTOR			FRN-90	FRN-80	FRS-50	FRS-40	FRS-35	5	832-485	832-143
30 HP MOTOR			FRN-100	FRN-100	FRS-60	FRS-50	FRS-40	5.6	832-421	832-472
40 HP MOTOR		†	FRN-150	FRN-150	FRS-80	FRS-70	FRS-50	6.25	832-135	832-498
50 HP MOTOR			FRN-175	FRN-175	FRS-100	FRS-80	FRS-70	7	832-402	832-144
60 HP MOTOR			FRN-200	FRN-200	FRS-125	FRS-100	FRS-80	8	832-636	832-332
75 HP MOTOR		<u> </u>	FRN-250	FRN-250	FRS-150	FRS: 125	FRS-100	9	832-486	832-366
100 HP MOTOR		-	FRN-350	FRN-300	11110100	FRS-150	FRS-125	10	832-136	832-145
125 HP MOTOR		<del> </del>	FRN-450	FRN-400	<del>+</del> -	FRS-200	FRS-150	12	832-481	832-471
150 HP MOTOR			FRN-500	FRN-450	+	FRS-225	FRS-200	15	832-347	832-146
200 HP MOTOR		1	1	FRN-600		FRS-300	FRS-250	175	832-137	B32-448
		<del> </del>	<del> </del>		<del>                                     </del>	-	1110 250	20	832-298	B32-147
2 KW HEATER	FRN-20	FRN-12	FRN-7	FRN-7	+	FRS-4-1/2	FRS-3-2/10	25	832-461	832-148
3 KW HEATER	FRN-30	FRN-15	FRN-1C	FRN-10	FRS-6-1/4	FRS-5-6/10	FRS-4-1/2	30	832-627	832-626
5 KW HEATER	FRN-50	FRN-25	FRN-15	FRN-15	FRS-10	FRS-8	FRS-6-1/4	35	832-138	832-149
7-1/2 KW HEATER			FRN-25	FRN-25	FRS-15	FRS-12	FRS-10	40	832-653	832-499
10 KW HEATER			FRN-30	FRN-30	FRS-25	FRS-17-1/2	FRS-12	45	832-139	832-622
15 KW HEATER		<del></del>	FRN-45	FHN-45	FRS-35	FRS-25	FRS-20	50	832-487	832-500
CONTROL CIRCUIT	-	<del></del>	1	<del></del>	17770	111020	1110-20	60	832-574	832-1115
XFMR VOLTAGE	1/2 KV	Α.	1 KVA.		1-1/2 KVA.	2	KVA.	70	832-140	832-501
110-120	FRN-7		FRN-15		FRN-17-1/2	FRN-2		80	B32-477	832-502
200-208	FRN-4	<del></del>	FRN-8	-+-	FRN-12	FRN-		100	832-476	832-847
220-240	FRN-3-1/	2	FRN-7		FRN-10	FRN		110	832-488	832-443
346-416	FRS-2-8/	10	FRS-4		FRS-6-1/4	FRS-F		125	832-489	832-1002
440-480	FRS-2-1/		FRS-3-1/2		FRS-5-6/10	FRS-7		150	832-478	832-1026
550-600	FRS-2	-	FRS-3-1/2		FRS-4-1/2			175	832-490	832-1104
SECONDARY FUSE		10	FRN-12		FRN-15	FRS-5		200	832-1025	832-1040
CONSULT YOUR							:0	225	1	832-1033
FOR POWER SY						=		250	832-621	832-444
					ALLO ADOVE.			300	832-1034	832-1041
								350	832-1035	<del>                                     </del>
								300	302-1000	<del></del>

#### STARTER PART NO.S THREE-PHASE, 120 VAC CONTROL COIL

#### MAIN POWER TERMINAL **BLOCK PART NO.S**

STARTER	SC	2·D	Δ.	-8
SiZE	OPEN TYPE	NEMA 1 ENCL	OPEN TYPE	NEMA 1 ENC
00	833-2570			
0	833-1884	833 1360	833-1362	833-1979
1	833-1885	833-970	833-1363	833-1904
2	833-1886	833-929	833-1447	833-1838
3	833-1197	833-1029	833-1544	833-1626
4	833-2098	833-1023	833-1298	833-1623
5		833-2178*		
• FU	LL VOLTAGE 20	V COIL		·

	033	4
VOLTAGE	200 V COII	

AMPS	PART NO.
30	832-780
70	832-781
125	832-782
250_	832-964

# MOTOR AMP DRAWS & STARTER SIZING AMP DRAWS BASED ON NEC TABLE 430-150. VOLTAGE-THREE PHASE

				OLIAGI	1 1 1 1 1		J			
HORSE-	:	200	2	230	3	80	-4	60	- 6	00
POWER	AMPS	STARTER	AMPS	STARTER	AMPS	STARTER	AMPS	STARTER	AMPS	STARTER
1/2	2.5	00	2	00	1.2	00	1	00	1	00
3/4	3.5	00	3	00	1.7	00	1.5	00	1	00
,	4.0	00	3.5	00	21	00	2	00	1.5	00
1-1/2	5.5	00	5	00	3.1	00	2.5	00	2	00
2	7.5	0	7	0	4.1	00	3.5	00	3	00
. 3	11	0	9.5	0	5.8	0	5	0	4	0
5	17	1	15	1	9.2	0	7.5	0	6	- 0
7-1/2	24	1	22	1	13.3	1	11	1	9	1
10	31	2	28	2	16.9	1	14	1	11	1
15	46	3	42	2	25 4	2	21	5	17	2
20	59	3	54	3	32.6	2	27	2	22	2
25	75	3	68	3	41.1	2	34	2	27	2
30	88	4	80	3	48.4	3	40	- 3	32	3
40	114	4	104	4	62.9	3	52	3	41	3
50	143	5	130	4	78.6	3	65	3	52	3
60	169	5	154	5	93.2	4	77	4	62	4

# MOTOR AMP DRAWS & STARTER SIZING AMP DRAWS BASED ON NEC TABLE 430-148. VOLTAGE-SINGLE PHASE

832-1036

832-1037

832-1038

832-1039

400

450

500

600

		JLIAGE	:-5ING	LE PHA	5E	
HORSE-		115		200		230
POWER	AMPS	STARTER	AMPS	STARTER	AMPS	STARTER
1/6	44	00	2.4	00	2.2	00
1/4	5.8	00	3.2	00	29	00
1/3	7.2	00	4	00	3.6	00
1/2	9.8	0	5.4	00	4.9	00
3/4	13.8	0	7.6	00	6.9	00
1	16	0	8.8	0	8	00
1-1/2	20	1	11	0	10	0
2	24	1	13.2	0	12	0
3	34	2	18 7	1	17	1
5	56	3	30.8	2	28	2

## CONTROL CIRCUIT TRANSFORMER AMP DRAWS

KVA		VOLTAG	SE-THRI	E PHAS	SE.
.,,	208	230	380	460	575
1/2	24	2.2	1.1	13	8 प्र
1	5	4.3	2.6	2.1	1.7
1-1/2	7.5	6.5	3.9	3.3	2.6
-2	10	8.7	5.3	4.3	3.5

WHEN SIZING TOTAL BOILER AMP DRAW USE 125% OF THE LARGEST LOAD.

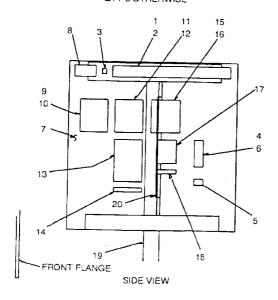
#### OIL HEATER AMP DRAWS

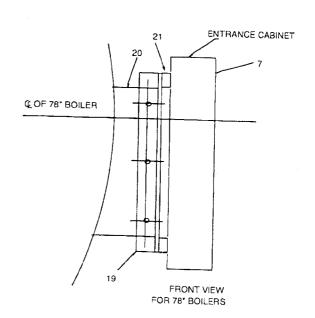
			- Table 1	U: 17(1)	-
кw		VOLTAG	E-THRE	E PHAS	Ε
RATING	200	230	380	460	600
3	8.3	7.5	4.6	3.8	3
5	13.9	12.6	7.6	6.3	5
7-1/2	20.8	18.8	11.4	9.4	7.5
ו סד	278	25.1	15.2	12.6	10

BILL OF MATERIAL FOR ENT. BOX

ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPTION
1	1	434-61	TERMINAL STRIP, 25 TERMS		
2	1	118-1865	PLATE, I.D. FOR TERM, STRIP		C8
3	1	884-78	GROUND LUG		C8
4	1	848-223	FUSE BLOCK, CONTROL CIRCUIT	<del>                                     </del>	C8
5	1	118-297	NAMEPLATE, DECAL CONTROL CIRCUIT	<del></del>	C8
6	1	832-347	FUSE, FRN-15	<del>                                     </del>	CB
	1	848-1083	ENT. BOX (18 X 15 X 6) (NEMA 1)	FUEL 700	C8
7	1	848-338	ENT. BOX (24 X 18 X 6) (NEMA 1)	FUEL 100, 101, & 200	↓ .
Ī	1	848-375	ENT. BOX (24 X 24 X 6) (NEMA 1)	FUEL 400 & 600 & "LE"	C8
8	1	SEE TABLE	MAIN POWER TERMINAL BLOCK	<del>+</del>	L
9	3.	SEE TABLE	BLOWER MOTOR FUSE	DETERMINED BY TOTAL AMP LOAD	C8
10	•	SEE TABLE	BLOWER MOTOR FUSE BLOCK	-	C8
11	3	SEE TABLE	AIR COMPRESSOR MOTOR FUSE	1.	CB
12		SEE TABLE	AIR COMPRESSOR MOTOR FUSE BLOCK		Св
13	1	SEE TABLE	AIR COMPRESSOR MOTOR STARTER	· · · · · · · · · · · · · · · · · · ·	C8
14	1	118-1667	AIR COMPRESSOR EMBLEM	<u></u>	C8
15	3	SEE TABLE	OIL HEATER FUSE	W/ ITEMS 11, 12, & 13	C8
16	•	SEE TABLE	OIL HEATER FUSE BLOCK		C8
17	1	833-2197	OIL HEATER CONTACTOR	<del></del>	C8
18	1	118-299	OIL HEATER EMBLEM	W/ITEMS 15 & 16	CB
19		8-275	UNIVERSAL UPRIGHT	W/ ITEMS 15, 16, & 17	C8
20	1	8-3186	BRACKET, E-BOX	-	
		8-3222	E-BOX CROSSBAR	78" BOILERS	
21		8-3223	<del></del>		
- F	1		E-BOX CROSSBAR		
		8-3224	E-BOX CROSSBAR		

- = QTY 1 ON VOLTAGE 240, < QTY 3 OTHERWISE
- = QTY 1 ON VOLTAGE 240, < QTY 3 OTHERWISE





#### BLOWER MOTOR ITEM 1

_				50 HZ.				
BOILER		MOTOR	C	DP	TEFC	TEFC &	MOTOR	ODP
H.P.	FUEL	H.P.	200-230- 460V	600V	200-230- 460V	200-230- 460V	H.P.	220-380V
250	GAS	7-1/2	894-2431	894-2432	894-3171	894-3396	7-1/2	894-2433
250	OIL & COMB	7-1/2	894-2431	894-2432	894-3171	894-3396	10	894-2449
300	GAS	7-1/2	894-2431	894-2432	894-3171	894-3396	10	894-2449
300	OIL & COMB.	10	894-2447	894-2448	894-3272	894-3399	15	894-2465
	GAS	15	894-2463	894-2464	894-3215	894-3402	15	894-2465
350	OIL & COMB.	15	894-2463	894-2464	894-3215	894-3402	20	894-2477

#### ITEM 26, 27, 30, & 32 TABLE

BOILER H.P.	QTY.	ITEM 26	QTY.	ITEM 27	QTY.	ITEM 30	QTY.	ITEM 32
250	2	848-10	2	848-101	1	848-371	1	848-151
300	2	848-85	2	848-307	1	848-6	1	848-6
350	2	848-86	2	848-287	- 1		Ι.	

NOTES: 1. MOTOR SIZES BASED ON SEA LEVEL.

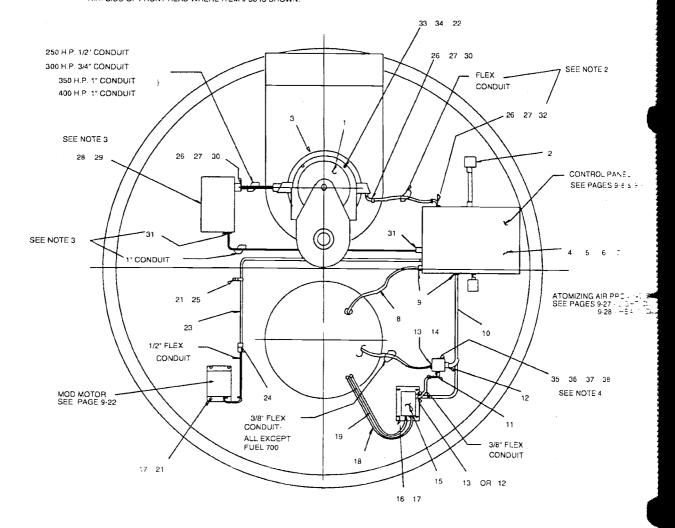
- 2. ITEM 32 AND FLEX CONDUIT USED AS SHOWN ON NON-HAWK ONLY.
- 3. ITEMS 28, 29, 31, AND 1" CONDUIT USED AS SHOWN ON HAWK ONLY.
- 4. FOR FUEL 700 ONLY, USE 2 OF ITEM #38 AND PLUG HOLES ON R.H. SIDE OF FRONT HEAD WHERE ITEM # 35 IS SHOWN.

#### STARTER BRACKET TABLE ITEM 29

ITEM 29 P/N.	USED W/STARTER P/N.
8-2938	833-970
8-2939	833-929
8-2943	833-1029

#### BLOWER MOTOR STARTER ITEM 28

MOTOR		VOLTAGE	
H.P.	200	220 & 230	380-600
7-1/2	833-970	833-970	833-970
10	833-929	833-929	833-970
15	833-1029	833-929	833-929



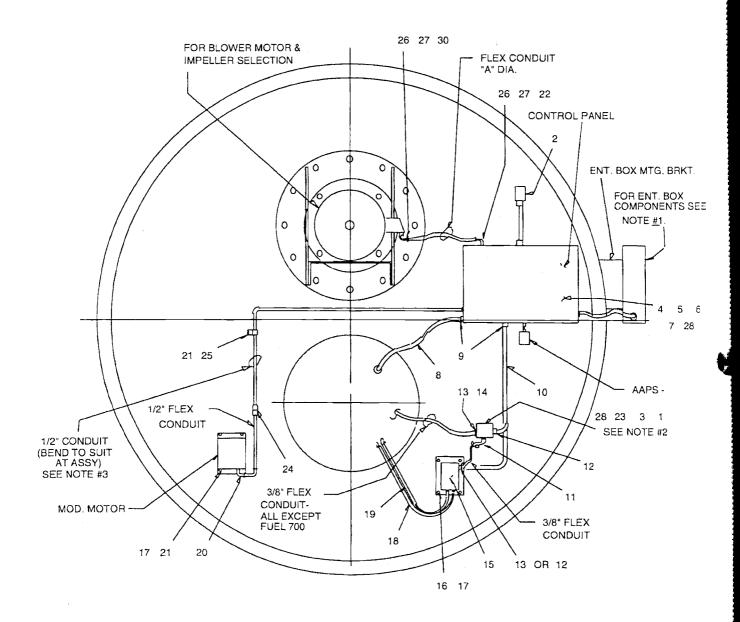
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	SEE TABLE	BLOWER MOTOR	
2	1	817-436	CAPS	· .
3	1	255-A-26	ADAPTER RING	
4	4	841-659	STUD, 5/16"-18 X 1-5/8" LG.	<del>-                                    </del>
5	4	869-36	NUT, HEX 5/16*	·
6	4	952-114	LOCKWASHER, 5/16"	
7	4	77-A-57	SPACER, 9/16" O.D. X 5/16" LG.	<u> </u>
8	1	817-1742	SCANNER ASSEMBLY	
9	2	848-325	CONNECTOR, 1/2" STRAIGHT	<u> </u>
	1	113-A-11		<u>·</u>
10	1	113-B-7	CONDUIT, JUNCTION BOX TO PANEL	ALL EXCEPT FUEL 700
11	1	848-16	CONDUIT, JUNCTION BOX TO PANEL	700
12	1		CONNECTOR BOX, 3/8" X 90	
13	1-1-	848-382	CONNECTOR, 1/2" X 90	·
14	2	848-3	CONNECTOR, 2 SCREW TYPE, 3/8*	-
	<del> </del>	848-100	BUSHING, ANTI-SHORT 3/8"	
15	1	832-118	IGNITION TRANSFORMER	OIL ONLY 60 HZ
	1	832-107	IGNITION TRANSFORMER	GAS & COMB. 60 HZ
	1	832-286	IGNITION TRANSFORMER	ALL 50 HZ
16	4	860-7	MACHINE SCREW, 1/4"-20 X 1/2" LG.	
17	8	952-92	LOCKWASHER, 1/4"	-
18	1	292-95	IGNITION CABLE	
19	1	292-66	IGNITION CABLE	OIL ONLY
20	1	848-10	CONNECTOR, SQUEEZE TYPE 1/2" X 90	
21	5	868-137	CAPSCREW, 1/4"-20 X 1" LG.	
22	4	868-133	BOLT, HEX HD 3/41-10	7-1/2 H.P. B.M.
	4	868-199	BOLT, HEX HD 3/4"-10	10, 15, 20 H.P. B.M.
23	1	113-B-8	CONDUIT, MOD MOTOR TO PANEL	
24		848-473	COUPLING, 1/2" EMT. X 1/2" FLEX	
25	1	928-14	CLAMP, CONDUIT 1/2"	
26	<u>.</u>	SEE TABLE	CONNECTOR, SQUEEZE TYPE	
27	·	SEE TABLE	BUSHING, ANTI-SHORT	
28	1	SEE TABLE	STARTER	HAWK ONLY
29	1	SEE TABLE	STARTER BRACKET	HAWK ONLY
30	·	SEE TABLE	WASHER, REDUCING	HAVE ONLY
31	2	848-407	CONNECTOR, STRAIGHT I"	HAWK ONLY
32	-	SEE TABLE	WASHER, REDUCING	<del></del>
33	4	952-95	LOCKWASHER, 3/4"	NON-HAWK ONLY
34	4	869-18	NUT, HEX 3/41-10	<del></del>
35	1	848-273	BOX, OUTLET, 4" SQ. X 2-1/8" DEEP	<u> </u>
36	1	848-248	COVER, OUTLET BOX	ALL EXCEPT FUEL 700
37	2	952-92	LOCKWASHER, 3/4"	ALL EXCEPT FUEL 700
38	2	868-135	CAPSCREW, 1/4*-20 X 1/2" LG.	ALL EXCEPT FUEL 700

NOTES: 1. NOTOR SIZES BASED ON SEA LEVEL.

<sup>2</sup> ITEM 32 AND FLEX CONDUIT USED AS SHOWN ON NON-HAWK ONLY.

<sup>3.</sup> ITEMS 26, 29, 31, AND 1° CONDUIT USED AS SHOWN ON HAWK ONLY

<sup>4.</sup> FOR FUEL 700 ONLY, USE 2 OF ITEM #38 AND PLUG HOLES ON R.H. SIDE OF FRONT HEAD WHERE ITEM # 35 IS SHOWN.



	CONDUIT DIAMETER				
ĺ	H.P.	250	300	350	
	"A"	1/2"	3/4"	1"	

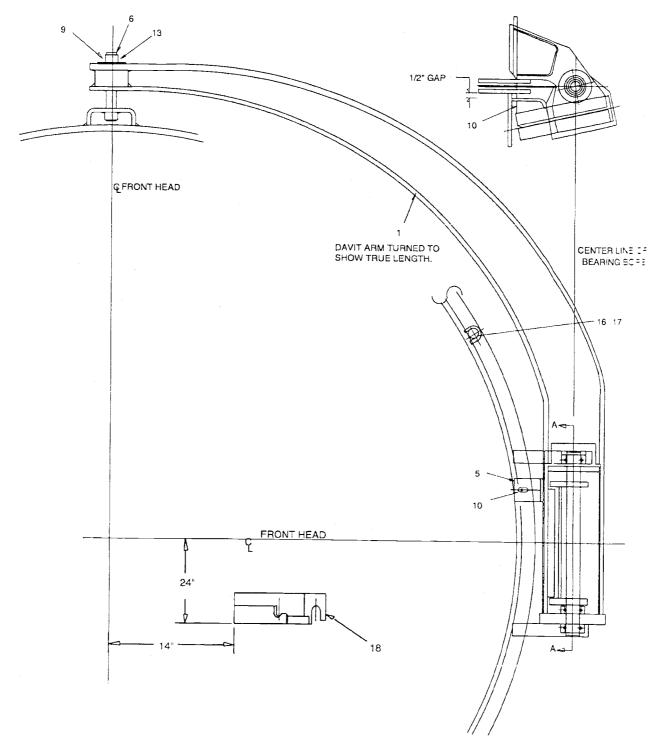
1		PART NO.	DESCRIPTION	USED ON
	2	868-135	CAPSCREW, 1/4"-20 X 1/2" LG.	_
2	1	817-436	CAPS	
3	2	952-92	LOCKWASHER, 3/4"	ALL EXCEPT FUEL 700
4	4	841-659	STUD, 5/16"-18 X 1-5/8" LG.	ALL EXCEPT FUEL 700
5	4	869-36	NUT, HEX 5/16"	<del>-</del>
6	4	952-114	LOCKWASHER, 5/16"	<del></del>
7	4	77-A-57	SPACER, 9/16" O.D. X 5/16" LG.	
8	1	817-1742	SCANNER ASSEMBLY	<del></del>
9	2	848-325	CONNECTOR, 1/2" STRAIGHT	<del>-</del>
40	1	113-A-11	CONDUIT, JUNCTION BOX TO PANEL	<u> </u>
10	1	113-B-7	CONDUIT, JUNCTION BOX TO PANEL	ALL EXCEPT FUEL 700
11	1	848-16	CONNECTOR BOX, 3/8" X 90	700
12	1	848-382	CONNECTOR, 1/2" X 90	-
13	1	848-3	CONNECTOR, 2 SCREW TYPE, 3/8"	
14	2	848-100	BUSHING, ANTI-SHORT 3/8"	-
1,5	1	832-118	IGNITION TRANSFORMER	
15	1	832-107		OIL ONLY 60 HZ
Ì	1	832-286	IGNITION TRANSFORMER IGNITION TRANSFORMER	GAS & COMB. 60 HZ
16	4	860-7		ALL 50 HZ
17	8	952-92	MACHINE SCREW, 1/4"-20 X 1/2" LG.	-
18	1	292-95		
19	1	292-66	IGNITION CABLE	-
20	1	848-10	<del></del>	OIL ONLY
21	5	868-137	CONNECTOR, SQUEEZE TYPE 1/2" X 90 CAPSCREW, 1/4"-20 X 1" LG.	-
22		SEE TABLE		
23	1	848-248	WASHER, REDUCING COVER, OUTLET BOX	NON-HAWK ONLY
24	1	848-473		ALL EXCEPT FUEL 700
25	1	928-14	COUPLING, 1/2" EMT. X 1/2" FLEX CLAMP, CONDUIT 1/2"	-
26		SEE TABLE	<del></del>	<u> </u>
27	-	SEE TABLE	CONNECTOR, SQUEEZE TYPE BUSHING, ANTI-SHORT	-
28	1	848-273	<del></del>	•
29	1	8-A-2707	BOX, OUTLET, 4" SQ. X 2-1/8" DEEP STARTER BRACKET	ALL EXCEPT FUEL 700
30		SEE TABLE	WASHER, REDUCING	SEE NOTE #6

## ITEM 22, 26, 27, & 30 TABLE

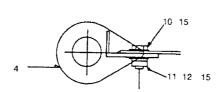
BOILER H.P.	QTY	ITEM 22	QTY	ITEM 26	QTY	ITEM 27	QTY	ITEM 30
250	1	848-151	2	848-10	2	848-101		848-371
300	_ 1	848-6	2	848-85	2	848-307	1	848-6
350	]	:_	2	848-86	2	848-287	-	-

## NOTE:

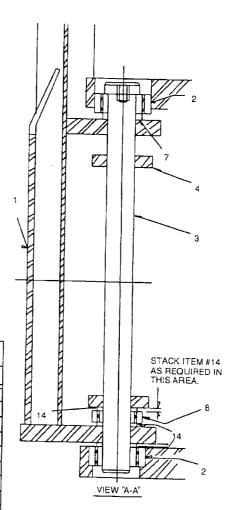
- BLOWER MOTOR STARTER MOUNTED IN ENT. BOX FOR ALL HAWK AND ANY NON-HAWK W/ SIZE 4 STARTER OR LARGER. ALL OTHER STARTERS ARE MOUNTED IN CONTROL PANEL.
- 2. FOR FUEL 700 ONLY, USE 2 OF ITEM #1 AND PLUG HOLES ON R.H. SIDE OF FRONT HEAD WHERE ITEM #28 IS SHOWN.
- 3. 1/2" CONDUIT FROM CONTROL PANEL TO MOD. MOTOR TO RUN BELOW MOTOR CASSETTE ASSEMBLY (AS SHOWN) SO AS NOT TO INTERFERE W/FUTURE CASSETTE REMOVAL.

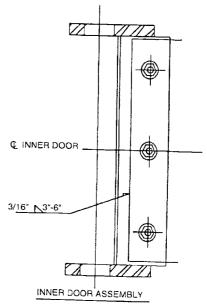


FRONT DAVIT STANDARD CB



			BILL OF MATERIAL DAVIT ASSEMBLY, L.H. & R.H.	
ITEM	ΩΤΥ	PART No.	DESCRIPTION	USED ON
Ī,	1	287-C-38	ARM ASSY., FRONT DAVIT (RIGHT HAND)	78"
	1	287-39	ARM ASSY., FRONT DAVIT (LEFT HAND)	78"
2	2	807-31	BEARING, BALL, DOUBLE	78"
3	1	56-A-26	PIN, HINGE FRONT	78"
4	1	138-B-15	HINGE, BRACKET ASSY., INTERM. DOOR	78"
5	1	11-A-14	TAB, RESTRAINT, FRONT HEAD	<del>- 10</del>
6	1	869-398	NUT - ELASTIC LOCKNUT 1"-8	78"
7	1	77-386	SPACER (77A385)	10
8	1	807-322	BEARING, THRUST	78"
9	1	841-658	STUD, 1"-8 X 8" LG.	
10	4	868-93	CAP SCREW, HEX. HD 1/2-13 x 1-1/4"	78"
11	3	952-94	LOCKWASHER - 1/2"	<del> </del>
12	3	869-15	NUT, HEX. 1/2-13	<del></del>
13	1	952-194	WASHER, FLAT - BRASS 1"	78"
14	5	952-245	WASHER, SPECIAL - 1/16" THK, X 1.406" I.D.	
15	6	952-286	WASHER, FLAT 1/2"	78"
16	13	868-819	CAPSCREW, HEX. HD, 7/8-9 X 6" LG.	+
17	13	952-103	WASHER, FLAT 7/8"	+
18	1	3-B-3171	BRACKET, MOUNTING, OILGUN ASSY	<del> </del>

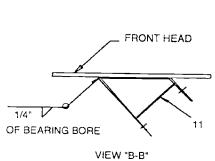


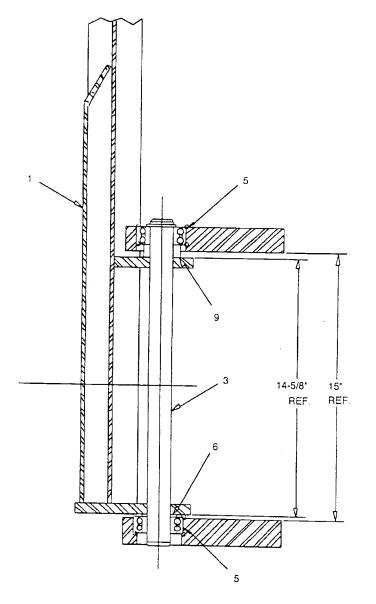


# NOTE: LOCATION OF THE BRACKET IDEALLY TO BE ON THE RIGHT SIDE OF IGNITION TRANSFORMER. IF THIS LOCATION IS NOT AVAILABLE, BRACKET IS TO BE WELDED TO FRONT HEAD AS SPACE ALLOWS. 8 1/2" GAP 10 FRONT HEAD ę DAVIT ARM TURNED TO $-\ _1$ SHOW TRUE LENGTH. SHELL O.D. 78" O.D. FRONT HEAD FRONT HEAD 7-1/2" 24' (SEE NOTE) "B" "B" T14" (SEE NOTE)

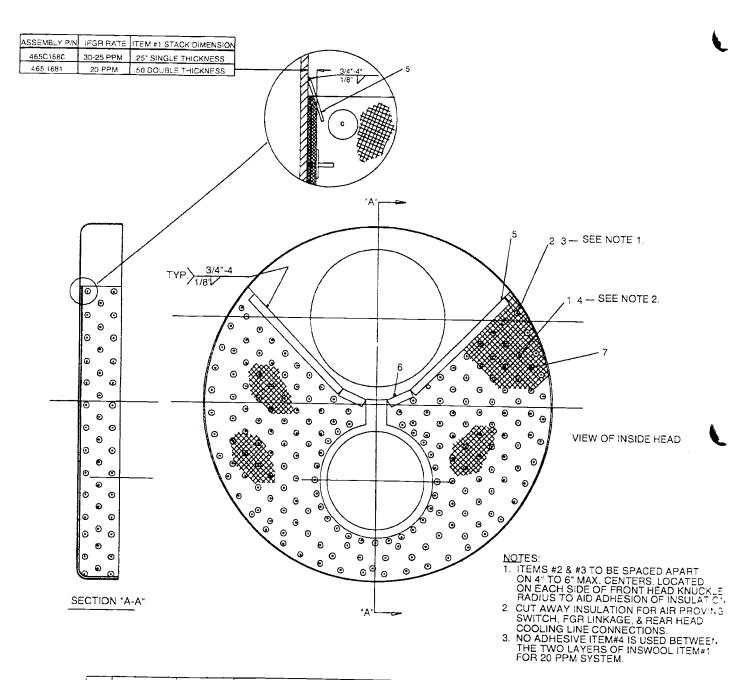
FRONT DAVIT CB-LE

L.H. MIRROR IMAGE R.H. AS SHOWN			BASIC BILL OF MATERIAL FOR FRONT DAVIT ASSY, R.H. & L.H.			
BEO PART NO	REO	PART NO.	LITEN	REQ		DESCRIPTION
1 287-49	1 1	287C48	1	·	SEE TABLE	ARM ASSEMBLY, FRONT DAVIT
			2	1	869-320	NUT, HEX., HEAVY. 1"-8
			3_	1_1_	56A26	PIN, HINGE, FRONT
			4	1	11A14	TAB, RESTRAINT, FRONT HEAD
			5	2	807-31	BEARING, BALL, DOUBLE ROW
			6	1_	952-245	WASHER (SPECIAL)
			7	1	868-93	CAPSCREW, HEX. HD. 1/2"-13 X 1-1/4" LG.
			8	1	952-194	WASHER, FLAT, BRASS 1"
			9	_1	77-386	SPACER, DAVIT (77A385)
			10	_1	841-1594	STUD, 1"-8 X 17"LG. SPEC.A307TOE 1-1/2"-TOE 3"
			11_	1	8B3171	BRACKET, MOUNTING, OIL GUN ASSY





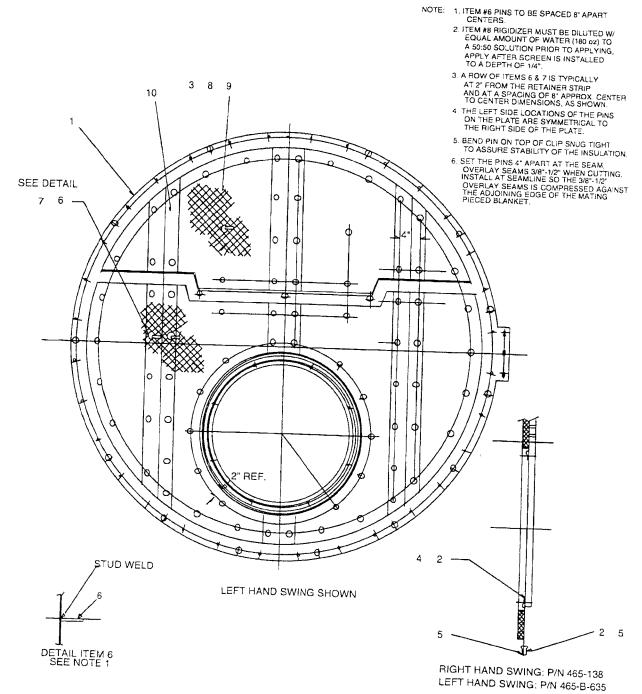
SECTION "A"-"A"

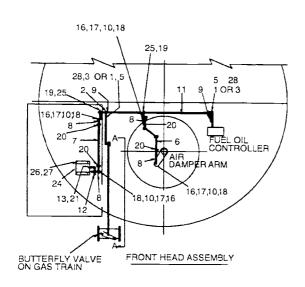


	25-30 PPM	20 PPM	78" GENERAL BILL OF MATERIAL					
ļ		465-1681						
ITEM	REQ.	REQ.	PART NO.	DESCRIPTION				
1	57 SQ FT	114 SO FT	872-688	BULK INSULATION, INSLWOOL, 1/4" THK,				
2	150	150	903-297	PIN, WELDING, #10 GA, X 2-1/2" LG, ST, STL.				
_3_	150	150	828-39	CLIP, WELDING ST. STL				
14	128 OZ	128 OZ.	872-512	ADHESIVE, SCOTCHGRIP #42NF				
5	22	2	971-355	STRIP, 14 GA, x 1-1/2" x 32-1/2" LG.				
6	2	2	971-355	STRIP, 14 GA. x 1-1/2" x 9-1/2" LG.				
7	57 SQ FT	57 SQ FT	930-57	SCREEN 1/2" 19 GA. GALV.				

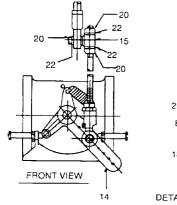
FRONT HEAD INSULATION (LE ONLY)

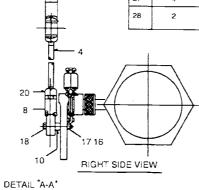
ITEM	QTY	PART NO.	DESCRIPTION
1	1	SEE TABLE	INTERMEDIATE FRONT HEAD
2	41	841-551	RIVET, SPLIT ROUND HEAD (841-A-551)
3	30 SQ FT	872-500	BULK INSULATION, BLANKET, 1-1/2" THK, 2400, 8#
4	1	32-A-898	GASKET, HEAD PLATE
5	2	32-B-899	GASKET, FRONT AND REAR HEAD
6	78	903-182	PIN, WELDING, #10 GA. X 4" LG.
7	78	828-39	CLIP. WELDING, #10 GA. X 4" LG.
8	180 oz	872-443	
9	30 SQ FT	930-135	RIGIDIZER, COATING CEMENT, CERA-PREG (SEE NOTE 2) SCREEN, ST. STL
10	8 SQ FT	872-688	INSULATION, INSWOOL PAPER, 1/4" THK., AP GREEN

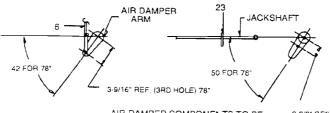




, .	SEE	NO	TE 5	& 6	ASIC BILL OF MATERIAL FOR 78 DIA. BOILER	
ITEM			CME	PART NO.	DESCRIPTION	WHERE USED
1	1	1	2	313-A-5	CAM ASSEMBLY	†
2	1	-	1	295-C-98	GAS VALVE STEM ASSEMBLY	
3	1	1	-	85-A-1926	SUPPORT - JACKSHAFT	
4	1	-	1	67-A-124	ROD LINKAGE, GAS VALVE	STD. 78"
	1	-	1	67-A-800	ROD LINKAGE, GAS VALVE	78" "LE"
5	1	1	2	853-454	GASKET	<del>-</del>
• 6		1		67-A-126	ROD DAMPER LINKAGE	STD. 78"
		1		67-A-801	ROD DAMPER LINKAGE	78" "LE
. 7		1		67-500	ROD LINKAGE, MOD. MOTOR (67-8-442)	STD. 78"
		1		67-192	ROD LINKAGE, MOD MOTOR (67-6-442)	78" "LE"
8		5		883-17	BALL JOINT	1
9		2		824-21	COLLAR	
10		5		10-A-288	BUSHING - BALL JOINT	†
11	-	1	1	74-204	JACKSHAFT	STD. 78"
	1	-	-	74-205	JACKSHAFT	STD. 78"
12		1		2-A-47	DRIVE ARM - MODUTROL MOTOR	1
13		1		10-A-91	BUSHING	
14		1_		287-A-24	GAS VALVE & ARM DAMPER	<del>                                     </del>
15	L	1		68-A-32	END ROD LINKAGE	
16		5		869-21	NUT HEX. 1/4-20	
17		5		869-234	NUT & LOCKWASHER	
18		5		868-139	BOLT, HEX HD 1/4-20 X 1-1/2" LG.	
19	-	4	4	860-101	SET SCREW 1/4-20 x 1/2"	
	4	-		860-39	SET SCREW 1/4-20 x 1/2"	<del></del>
20		8		869-22	NUT HEX. 3/8-24	
21		1		860-39	SET SCREW 1/4-20 x 3/8"	-
22		3		952-93	LOCKWASHER 3/8"	
23		•		NOT USED	•	-
		1		894-3470	MOD. MOTOR	NON-UL
24		1		894-3471	MOD. MOTOR	NON-HAWK
		1		894-3513	MOD, MOTOR	HAWK
25		2		2 A-47	DRIVE ARM	
26		4		868-137	BOLT, HEX HO 1/4-20 X 1" LG.	
27		4		952-92	LOCKWASHER 1/4"	
28		2		77-371	CAM SPACERS	FUEL 200, 400, 700



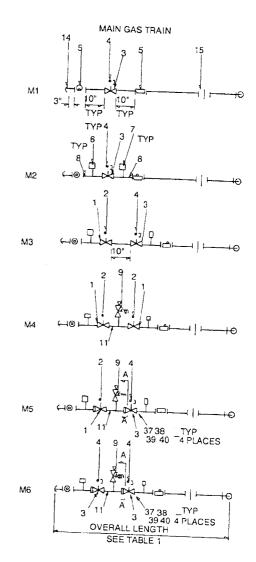




AIR DAMPER COMPONENTS TO BE SET AS SHOWN ABOVE.

2-3/8" REF. (4TH HOLE) 78"

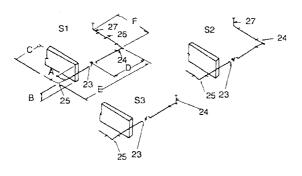
ITEM	YTD	P/N	DESCRIPTION	LICED ON
1	TABLE	1 - 940-4541	VALVE (STD)	USED ON
2		945-139	ACTUATOR (STD)	3" GTS 250-350 HP
3		940-4546	VALVE (POC)	2".2-1/2",3" GTS 50-350 HP
4		945-143	ACTUATOR (POC)	3" GTS 250-800 HP
5	2	941-130	LUBRICATED PLUG VALVE	2",2-1/2",3" GTS
7	1	507-6785	GAS PRESS. SENSOR	3" GTS
′	1			200-350 HP (HAWK)
		817-752	HIGH GAS PRESS, SWITCH	300-350 HP (STD)
8	2	<del></del>	HIGH GAS PRESS, SWITCH	ALL HP (HAWK)
	TABLE	1 157-1039	S.O. NIPPLE 1/2"	3" GTS (STD)
9		+	S.O. NIPPLE	ALL HP (HAWK)
9	<del></del>	948-2	MAIN VENT VALVE	3/4* VVS
	TABLE 1	948-54	MAIN VENT VALVE	1·1/4" VVS
11		157-1040	S.O. NIPPLE	3" GTS, 3/4" VVS
	2	157-1041 8-1002	S.O. NIPPLE	3" GTS, 1-1/4" VVS
12	2	B-1159	BRACKET	2", 2-1/2", 3' GTS
		+	BRACKET	MAXON 2", 2-1/2", 3" GTS
13		NOT USED	NOT USED	
-	1	919-99	CAPLUG	3" GTS
15	1	858-171	UNION	3" GTS
16	TABLE 1	948-197	PILOT VALVE	
17	TABLE 1	948-2	PILOT VENT VALVE	
8	11	918 356	PILOT REGULATOR	
9	1	507-1015	PILOT TUBING	250-350 HP
20	1	850-109	PILOT GAUGE	230-350 HP
21	SCHEM.	825-30	PILOT GAS COCKS	
2	1	845-194	ELBOW	
3	1	940-134	BUTERFLY VALVE 3"	125-800 HP
			DOTE THE TO VALVE 3"	150-350 HP



- THE ACTUATORS ARE INCLUDED W/ ITEMS #1 & 3 GAS VALVES.
- FOR ALL HAWK, ITEM #7 IS NOT USED AND REPLACE ITEM #8 WITH STANDARD PIPE NIPPLE.

ITEM	QTY	P/N	DESCRIPTION	USED ON	OPTION
24	1	157-81	ELBOW 3" W/ TEST CONN.	150-350 HP	B3
25	1	859-87	FIBOM 3.	250-350 HP	
26	_1	858-336	FLANGED UNION 3*	250-350 HP	B3
27	_ 1	847-562	ELBOW 4" X 3"	250-350 HP	1 - 12-1
	2	7-77	U-BOLT	3" GTS	1
29	4	952-114	LOCKWASHER	QTY 6 ON 4" GTS	1
30	4	952-133	WASHER	QTY 6 ON 4" GTS	
31	4	869-36	HEX NUT	QTY 6 ON 4" GTS	1
32	2	928-44	STRAP	QTY3ON4"GTS	1
33	2 -	952-92	LOCKWASHEH	QTY 3 ON 4" GTS"	1
34	2	952-145	WASHER	QTY3 ON 4" GTS	1
35	2	869-21	HEX NUT	QTY3 ON 4" GTS	1
36	2	868-404	CAPSCREW	QTY3 ON 4" GTS	1
41	2	8A15	GAS PILOT BRACKET	FUEL 101, 600	В3
42	2	868-135	CAPSCREW	FUEL 101, 600	





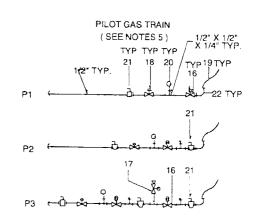


TABLE 1

BOILER HORSEPOWER SIZE	TRAIN	VENT VAL	AIN GAS		EMAT	IC	STARTER TRAIN SCHEMATIC		TRAIN MATIC	1	L LENGTH
	SIZE		STD & FM	IRI .	STD	FM	iRi	ALL INS.	STD & FM	lRI	M1,M2,
250	3"		1-1/4"	МЗ	МЗ	M5	S1	P1	P2		M6
300-350	3"	3/4"	1-1/4"	M5	M6	M5	S1	P1	P2	<del>  -</del>	80"

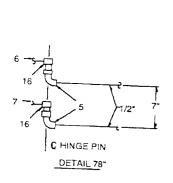
250	HO	RS	FP.	ED

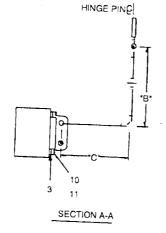
			ED LOOSE NO	OT SHOWN	
-	ITEN	QTY	PART NO.	ITEM T	USED ON
Į	18		506-508	PUMP	50 HZ
ļ		1	905-1342	PUMP	60 HZ
ł	19	-1-1	833-494	STARTER	
L	20		529-11	STRAINER	
		300	DED LIMMAN		

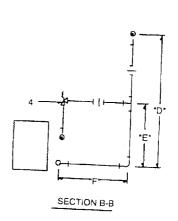
	300	- 350 HORSE	OWER	·
	SHIPF	ED LOOSE NO	OT SHOWN	
	OTY	PART NO.	ITEM	USED ON
18		506-509	PUMP	50 HZ
19		905-1340	PUMP	60 HZ
20		833-494	STARTER	-
		843-252	STRAINER	

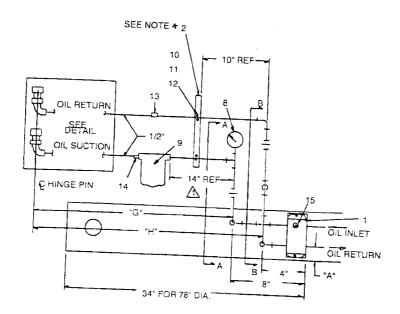
DIMENSION	5 78"	78" LE
A	4	4
В	16	14-1/4
	12	12
D	25-1/2	24-3/4
E	11-1/2	11-1/2
F	12	12
G	27	27
н	31	31

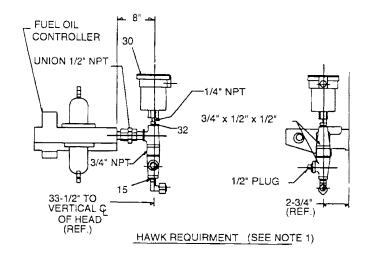
ITEM	QTY	PART No.	DESCRIPTION	11000 011
1	1	106-B-12		USED ON
2	_ 1	8-A-811	OIL TERMINAL BLOCK BRACKET	
3	2	70-A-55	SHIM	78"
4	1	940-2296	FULFLO VALVE	-
5	2	847-1715	JOINT, SWIVEL	·
6	1	507-7506	TURING RETURN (SEE NAME	
7	1	507-7503	TUBING, RETURN (SEE NOTE 6	\$ 7) 78" & 78" LE
	1	507-7506	TUBING, SUPPLY (SEE NOTE 6)	78*
8	1	850-61	TUBING, SUPPLY (SEE NOTE 7) GAUGE, PRESSURE	78" LE
9	1	843-252	STRAINER STRAINER	
10	2	868-99	CAPSCREW 5/16"	
	2	869-235	NUT & LW COMB. 5/16"	78"
12	2	928-45	PIPE STRAP	78"
3	1	847-530	COUPLING 3/4" x 1/2"	78"
4		847-152	BUSHING 3/4 X 1/2"	
5	1	858-1	1/4" PLUG SQ. HEAD	
6	2	845-313	ELBOW 1/2" NPT X 1/2" ODC	

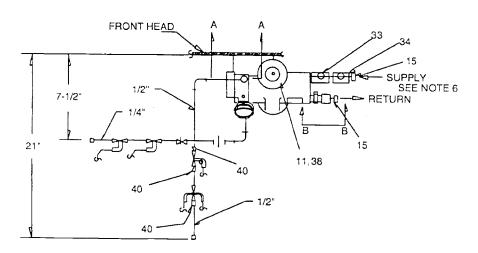


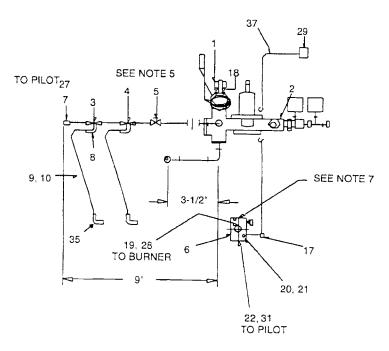


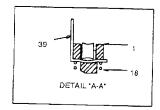


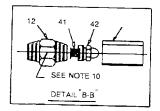






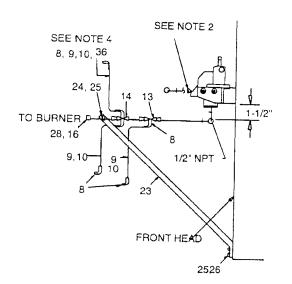






### NOTES:

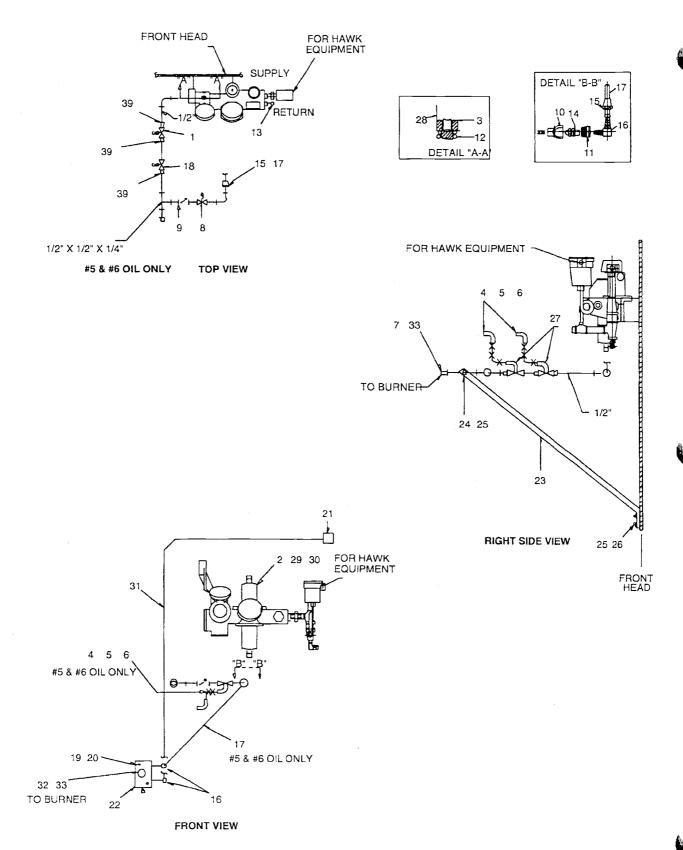
- WHEN HAWK IS REQUIRED CHANGE
  OIL SUPPLY PIPING BY ADDING
  HAWK COMPONENTS (ITEMS 30 AND
  32), AND PIPE PER HAWK REQUIRMENT.
  RETURN LINE PIPING DOES NOT CHANGE.
- 2. IF MODEL 100, REMOVE PLUG AND PROVIDE OIL PILOT PIPING AS SHOWN.
- 3. ALL DIMENSIONS ARE APPROX.
- 4. USED ONLY ON FM INSURANCE
- 5. USED ONLY ON IRLINSURANCE
- 6. FOR SUPPLY & RETURN PIPING. REFER TO PREVIOUS PAGES
- 7. FOR AIR COMPRESSOR PIPING TO AIR MANIFOLD BLOCK REFER TO AIR COMPRESSOR PIPING
- 8. ITEMS #33 & 34 ARE NOT USED WITH HAWK.
- 9. UNLESS OTHERWISE NOTED, ALL OIL PIPE TO BE SCH. 40 ASTM A120 WELDED BLACK STL. AND ALL FITTINGS TO BE 150# M.I..
- 10. STAMP NOZZLE SIZE ON FLAT SIDE OF ITEM 12. ITEMS 12, 41, 42, & 43 STOCKED AS: 277-121



├	OTY	<del></del>	BASIC BILL OF MATERIAL	
ITEM	OOL	PART NO	DESCRIPTION	USED ON
1	1	24-86	VALVE STEM (24-B-81)	250-350 H.P.
2	1	739-D-73	VALVE ASSEMBLY (FOC)	250-350 H.P.
3	↓	948-153	VALVE - SOLENOID 1/4" (OIL PILOT)	MODEL 100
4	1	948-153	VALVE - SOLENOID 1/4" (OIL PILOT)	
5	١,	941-914	VALVE - GATE 1/4"	MODEL 100; IRI ONLY MODEL 100; IRI ONLY
6	1	106-B-42	AIR MANIFOLD BLOCK	- MODEL TOO, THE ONLY
7	1	845-7	CONNECTOR MALE - 1/4" NPT x 1/4"	MODEL 100
8	5 4	848-3	CONNECTOR - SCREW TYPE 3/8"	ADD OTY, 1 IF FM INS
9	6 4	848-100	BUSHING 3/8"	ADD OTY, 2 IF FM INS
10	3 2	827-6	GREENFIELD - 3/8" (CUT TO FIT)	
11	4	952-93	LOCKWASHER 3/8"	ADD QTY, 1 IF FM INS
12	1	106-A-49	ORIFICE BLOCK	<del>-  </del>
13	1	SEE TABLE	VALVE, OIL SHUT-OFF	SEE TABLE
14	1	SEE TABLE	VALVE, OIL SHUT-OFF	SEE TABLE
15	2	845-312	CONNECTOR - MALE 1/2' NPT x 1/2'	SEE TABLE
16	1	858-360	COUPLING - FULL 1/2"	<del></del>
17	1	845-137	ELBOW - 1/8" NPT X 1/4" ODC	+
18	1	82-B-83	SPRING - COMPRESSION	
19	,	57-5103	SIZED PIPE - 1/2" X 16" LG. TBE.	<del>-   ·</del>
20	2	868-387	CAPSCREW, HEX HD. 1/4"-20 X 2-3/4"	<u> </u>
21	2	952-92	LOCKWASHER 1/4"	
22	1	845-9	ELBOW - 1/4" NPT X 1/4" ODC	<del></del>
23	1	8-B-2204	BRACKET	MODEL 100
24	1	841-1119	U-BOLT WITH NUTS	<del>                                     </del>
25	4	952-92	WASHER	<del>                                     </del>
26	2	868-136	CAPSCREW	<del>-</del>
27	1	507-B-1581	TUBING - OIL TO PILOT	
28	2	861-439	FLEXIBLE HOSE	MODEL 100
29	1	507-A-2072	ATOMIZING AIR SWITCH	<del>                                     </del>
30	1	817-2098	SENSOR - PRESSURE	<del>-</del>
31	1 :	507-A-1582	TUBING - AIR TO PILOT	HAWK ONLY
32	1	847-419	BUSHING - 1/2" x 1/4"	MODEL 100
33	1	817-1264	LOPS (SEE NOTE 8)	+AWK ONLY
34	1	817-922	HOPS (SEE NOTE 8)	+·
5	7	848-2	CONNECTOR, SQUEEZE TYPE 3/8" X 45	KEM. ONLY
6	1	848-16	CONNECTOR, SQUEEZE TYPE 3/8" X 90	MODEL 100
7	1 5	507-B-1529	TUBING, AIR SWITCH TO MANIFOLD	FM ONLY
8	4	868-157	CAPSCREW, HEX HD. 3/8"-16 X 1-1/4"	-  -
9	1	36-A-26	CAM BODY GUIDE	+
0	3	847-420	BUSHING - 1/2" X 3/8"	† ·
1	1	899-14	STRAINER, MONARCH #F-80	<u> </u>
2	1	899-51	NOZZLE, 30, H.V.MON. #F-80, 24 GPH.	<del></del>
			יייייייייייייייייייייייייייייייייייייי	

MAXIMUM QUANTITY SHOWN BASED ON REQUIREMENTS.

TEM	HP	NO INS.	FM	KEM	IRI	IRM	F & I
	250	948-154	948-154	948-154	948-154	948-154	948-154
13	300	948-154	949-183	948-154	948-154	948-154	949-183
	350	948-154	949-183	948-154	948-154	948 154	949-183
	250	948-154	948-154	949-183	949-154	948-154	949-154
14	300	948-154	949-183	949-183	949-183	948-154	949-183
	350	948-154	949-183	949-183	949-183	948-154	949-183



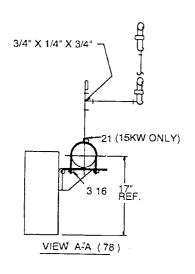
HEAVY OIL
OIL/AIR PIPING-FRONT HEAD
CB,CBLE

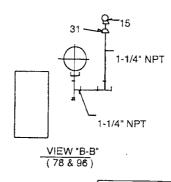
1 948-154 VALVE , SOLENOID  1 948-183 VALVE . SOLENOID  2 1 739-D-75 VALVE ASSEMBLY  3 1 24-86 VALVE STEM (24-B-81)  4 3 827-6 GREENFIELD - 3/8" (CUT TO FIT)  5 3 848-16 CONNECTOR - 3/8" x 9027  6 4 848-100 BUSHING - 3/8"  7 1 856-271 COUPLING - 1/2"  8 1 948-153 SOLENOID VALVE - 1/4"  9 1 940-710 CHECK VALVE - 1/4"  10 1 157-75 REDUCER - 1/2" x 1/4"  11 1 106-A-10 ORIFICE BLOCK  12 1 82-B-83 COMPRESSION SPRING  13 2 645-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-183 VALVE , SOLENOID  19 2 866-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  20 4 668-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG.  30 4 668-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	USED ON	OPTION
1 948-183 VALVE SOLENOID  2 1 739-D-75 VALVE ASSEMBLY  3 1 24-86 VALVE STEM (24-B-81)  4 3 827-6 GREENFIELD - 3/8" (CUT TO FIT)  5 3 848-16 CONNECTOR - 3/8" × 9027  6 4 848-100 BUSHING - 3/8"  7 1 858-271 COUPLING - 1/2"  8 1 948-153 SOLENOID VALVE - 1/4"  10 1 157-75 REDUCER - 1/2" × 1/4"  11 1 1 106-A-10 ORIFICE BLOCK  12 1 82-B-83 COMPRESSION SPRING  13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT. SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-183 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  20 4 868-157 CAPSCREW.HEX HD.3/8"-16 X 1-1/4" LG.  20 4 868-157 CAPSCREW.HEX HD.3/8"-16 X 1-1/4" LG.  20 5 5 -8-1503 SIZED PIPE - 1/2" X 16" LG. TBE.	250 HP ALL	<del>                                     </del>
3 1 24-86 VALVE STEM (24-B-81)  4 3 827-6 GREENFIELD - 3/8" (CUT TO FIT)  5 3 848-16 CONNECTOR - 3/8" × 9027  6 4 848-100 BUSHING - 3/8"  7 1 858-271 COUPLING - 1/2"  8 1 948-153 SOLENOID VALVE - 1/4"  9 1 940-710 CHECK VALVE - 1/4"  10 1 157-75 REDUCER - 1/2" × 1/4"  11 1 106-A-10 ORIFICE BLOCK  12 1 82-B-83 COMPRESSION SPRING  13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-154 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 1 06-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  20 4 868-157 CAPSCREW, HEX HD. 3/8"-16 X 1-1/4" LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	300-350 HP FM/F & I	A4
4 3 827-6 GREENFIELD - 3/8" (CUT TO FIT) 5 3 848-16 CONNECTOR - 3/8" x 9027 6 4 848-100 BUSHING - 3/8" 7 1 858-271 COUPLING - 1/2" 8 1 948-153 SOLENOID VALVE - 1/4" 9 1 940-710 CHECK VALVE - 1/4" 10 1 157-75 REDUCER - 1/2" x 1/4" 11 1 106-A-10 ORIFICE BLOCK 12 1 82-B-83 COMPRESSION SPRING 13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT 14 1 899-80 BURNER NOZZLE 15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC 16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT 17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY 1 948-154 VALVE , SOLENOID 18 1 948-183 VALVE , SOLENOID 19 2 868-387 CAPSCREW 1/4" 20 2 952-92 LOCKWASHER 1/4" 21 1 507-A-2072 ATOMIZING AIR SWITCH 22 1 106-B-42 AIR MANIFOLD BLOCK 23 1 8-B-2204 BRACKET 24 1 841-1119 U-BOLT 25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 31 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	250-350 H.P.	A4
Section	250-350 H.P.	A4
5         3         848-16         CONNECTOR - 3/8" x 9027           6         4         848-100         BUSHING - 3/8"           7         1         858-271         COUPLING - 1/2"           8         1         948-153         SOLENOID VALVE - 1/4"           9         1         940-710         CHECK VALVE - 1/4"           10         1         157-75         REDUCER - 1/2" x 1/4"           11         1         106-A-10         ORIFICE BLOCK           12         1         82-B-83         COMPRESSION SPRING           13         2         845-312         CONNECTOR - 1/2" ODC x 1/2" NPT           14         1         899-80         BURNER NOZZLE           15         1         845-8         NUT, SHORT - 4527 FLARED x 1/4" ODC           16         3         845-42         ELBOW - 1/4" ODC x 1/8" NPT           17         1         507-A-2648         PURGE LINE TUBING ASSEMBLY           1         948-154         VALVE , SOLENOID           18         1         948-183         VALVE , SOLENOID           19         2         868-387         CAPSCREW 1/4"           20         2         952-92         LOCKWASHER 1/4" <td< td=""><td></td><td></td></td<>		
6         4         848-100         BUSHING - 3/8"           7         1         858-271         COUPLING - 1/2"           8         1         948-153         SOLENOID VALVE - 1/4"           9         1         940-710         CHECK VALVE - 1/4"           10         1         157-75         REDUCER - 1/2" x 1/4"           11         1         106-A-10         ORIFICE BLOCK           12         1         82-B-83         COMPRESSION SPRING           13         2         845-312         CONNECTOR - 1/2" ODC x 1/2" NPT           14         1         899-80         BURNER NOZZLE           15         1         845-8         NUT, SHORT - 4527 FLARED x 1/4" ODC           16         3         845-42         ELBOW - 1/4" ODC x 1/8" NPT           17         1         507-A-2648         PURGE LINE TUBING ASSEMBLY           1         948-154         VALVE , SOLENOID           18         1         948-183         VALVE , SOLENOID           19         2         868-387         CAPSCREW 1/4"           20         2         952-92         LOCKWASHER 1/4"           21         1         507-A-2072         ATOMIZING AIR SWITCH           <	<del></del>	-
8 1 948-153 SOLENOID VALVE - 1/4" 9 1 940-710 CHECK VALVE - 1/4" 10 1 157-75 REDUCER - 1/2" x 1/4" 11 1 106-A-10 ORIFICE BLOCK 12 1 82-B-83 COMPRESSION SPRING 13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT 14 1 899-80 BURNER NOZZLE 15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC 16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT 17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY 1 948-154 VALVE , SOLENOID 18 1 948-183 VALVE , SOLENOID 19 2 866-387 CAPSCREW 1/4" 20 2 952-92 LOCKWASHER 1/4" 21 1 507-A-2072 ATOMIZING AIR SWITCH 22 1 106-B-42 AIR MANIFOLD BLOCK 23 1 8-B-2204 BRACKET 24 1 841-1119 U-BOLT 25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 10 4 868-157 CAPSCREW,HEX HD.3/6"-16 X 1-1/4" LG. 20 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	<u> </u>	-
9 1 940-710 CHECK VALVE - 1/4"  10 1 157-75 REDUCER - 1/2" x 1/4"  11 1 106-A-10 ORIFICE BLOCK  12 1 82-B-83 COMPRESSION SPRING  13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-183 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  10 4 868-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG.  20 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	-	-
10 1 157-75 REDUCER - 1/2" x 1/4"  11 1 106-A-10 ORIFICE BLOCK  12 1 82-B-83 COMPRESSION SPRING  13 2 B45-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-183 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  20 4 868-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG.  20 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	#5 & #6 OIL ONLY	+
11	#5 & #6 OIL ONLY	A4
12	#5 & #6 OIL ONLY	A4
12		<del>                                     </del>
13 2 845-312 CONNECTOR - 1/2" ODC x 1/2" NPT  14 1 899-80 BURNER NOZZLE  15 1 845-8 NUT, SHORT - 4527 FLARED x 1/4" ODC  16 3 845-42 ELBOW - 1/4" ODC x 1/8" NPT  17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-183 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  20 4 868-157 CAPSCREW, HEX HD.3/8"-16 X 1-1/4" LG.  20 1 507-B-1529 TUBING MANIFOLD TO AAPS  20 2 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	#5 & #6 OIL ONLY	A4
14	<u> </u>	A4
15		ļ
16   3   845-42   ELBOW - 1/4" ODC x 1/8" NPT     17	#5 & #6 OIL ONLY	A4
17 1 507-A-2648 PURGE LINE TUBING ASSEMBLY  1 948-154 VALVE , SOLENOID  18 1 948-183 VALVE , SOLENOID  19 2 868-387 CAPSCREW 1/4"  20 2 952-92 LOCKWASHER 1/4"  21 1 507-A-2072 ATOMIZING AIR SWITCH  22 1 106-B-42 AIR MANIFOLD BLOCK  23 1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4* LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	#5 & #6 OIL ONLY	
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18	#5 & #6 OIL ONLY	A4
19 2 868-387 CAPSCREW 1/4" 20 2 952-92 LOCKWASHER 1/4" 21 1 507-A-2072 ATOMIZING AIR SWITCH 22 1 106-B-42 AIR MANIFOLD BLOCK 23 1 8-B-2204 BRACKET 24 1 841-1119 U-BOLT 25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	250 HP NO INSUR./FM/IRI/F&I 300-350 HP NO INSUR.	
20 2 952-92 LOCKWASHER 1/4" 21 1 507-A-2072 ATOMIZING AIR SWITCH 22 1 106-B-42 AIR MANIFOLD BLOCK 23 1 8-B-2204 BRACKET 24 1 841-1119 U-BOLT 25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	250 HP KEM 300-350 HP	A4
20 2 952-92 LOCKWASHER 1/4" 21 1 507-A-2072 ATOMIZING AIR SWITCH 22 1 106-B-42 AIR MANIFOLD BLOCK 23 1 8-B-2204 BRACKET 24 1 841-1119 U-BOLT 25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	FM/F & I/KEM/IRI	
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1 106-B-42 AIR MANIFOLD BLOCK BRACKET  1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	-	
1 8-B-2204 BRACKET  24 1 841-1119 U-BOLT  25 2 952-92 WASHER  26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	·	A4
25 2 952-92 WASHER 26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.		A4
26 4 868-136 CAPSCREW 27 4 5 848-3 CONNECTOR - 3/8" 28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	+	A4
26 4 868-136 CAPSCREW  27 4 5 848-3 CONNECTOR - 3/8"  28 1 36-A-26 CAM BODY GUIDE  29 4 952-93 LOCKWASHER - 3/8"  30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG.  31 1 507-B-1529 TUBING MANIFOLD TO AAPS  32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	+	
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28 1 36-A-26 CAM BODY GUIDE 29 4 952-93 LOCKWASHER - 3/8* 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4* LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.		
29 4 952-93 LOCKWASHER - 3/8" 30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	<u> </u>	
30 4 868-157 CAPSCREW,HEX HD.3/8"-16 X 1-1/4" LG. 31 1 507-B-1529 TUBING MANIFOLD TO AAPS 32 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	-	A4
1 507-B-1529 TUBING MANIFOLD TO AAPS 12 1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.	-	
1 57-5103 SIZED PIPE - 1/2" X 16" LG. TBE.		
2 0 01-01-05 01-21-21 1/2 X 10 LG. TBE.	-	A4
	-	A4
44 • 3 847-420 BUSHING, 1/2" X 3/8"	250-350 H.P.	A4

MAXIMUM QUANTITY SHOWN BASED ON REQUIREMENTS.

HEAVY OIL
OIL/AIR PIPING-FRONT HEAD
CB,CBLE

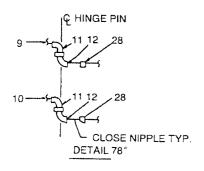
# **CUSTOMER SERVICE AND PARTS**





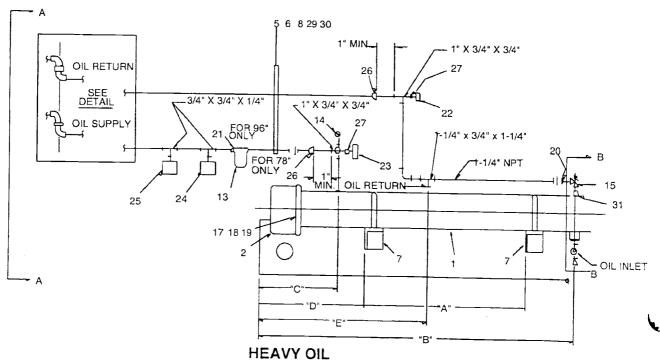
OIL HEATER RATINGS (KW)						
	#4 OIL	#5 & #6 OIL				
HP	ALL	STEAM		HOT WATER		
	PRESSURE	15	16-300	ALL		
250	5	7-1/2	7-1/2	7-1/2		
300-350 7-1/2		7-1/2	7-1/2	7-1/2		
NOTE: #4 OIL AND HOT WATER #5 & #6 OIL USE STRAIGHT ELECTRIC OIL HEATER						

STRAIGHT ELECTRIC OIL HEATER						
RATING	200 VOLT	230 VOLT	380 VOLT	460 VOLT	600 VOLT	
5 KW	832-948	832-929	832-932	832-933	832-934	
7-1/2 KW	832-936	832-937	832-949	832-938	832-939	



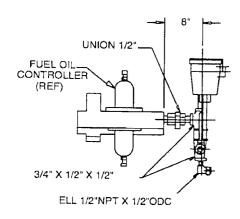
OIL PUMP (SHIP LOOSE)							
MODEL		VOLTAGE					
UD	20	0		230	380	460	600
HP 	50 HZ.	60 HZ.	50 HZ.	60 HZ.	50 HZ.	60 HZ.	60 HZ.
250-300	905-1072	905-1058	905-1072	905-1051	905-1072	905-1051	905-1065
350	-	905-1174	905-1180	905-1171	905-1180	905-1171	905-1177

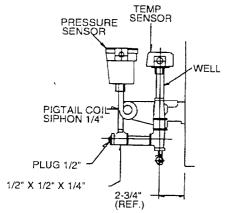
H.P.	RATING	DIM. "A"	DIM. "B"	DIM. "C"	DIM. "D"	DIM. "E"	
250	5 kw U.S.	9-1/2"				47-3/4"	į.
	5 kw CAN	9-1/2"	50-1/2"	35-1/4"	37-1/2"	45-1/2"	٧
300, 350	7-1/2 kw	23"	63"	35-1/4"	37-1/2"	55-3/4"	



OIL/AIR PIPING-FRONT HEAD CB,CBLE

STEAM-ELECTRIC OIL HEATER						
RATING	200/230 VOLT	380 VOLT	460 VOLT	600 VOLT		
5 KW	832-288	832-1576	832-289	832-290		
7-1/2 KW	832-509	832-1577	832-510	832-520		



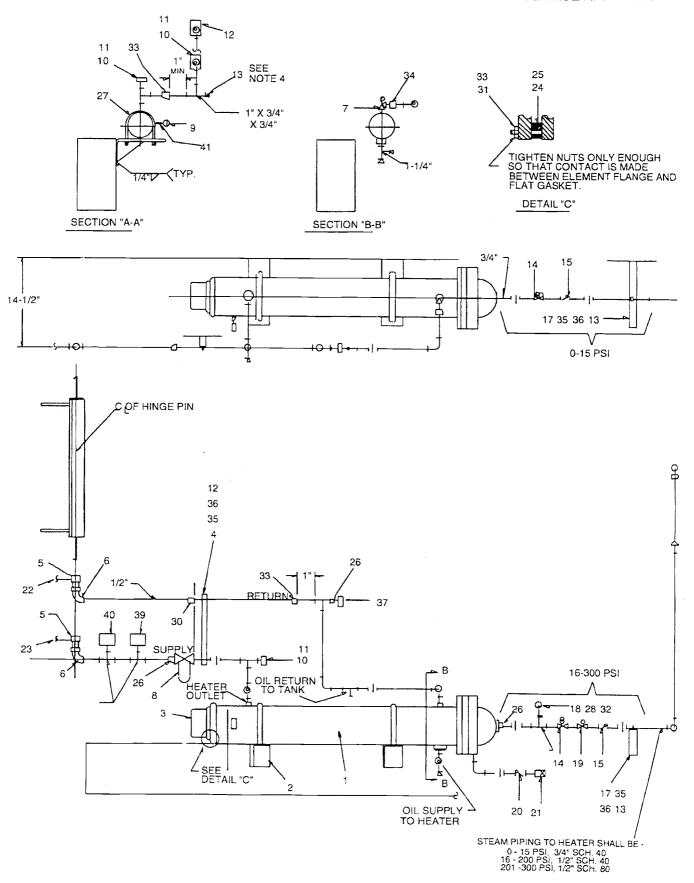


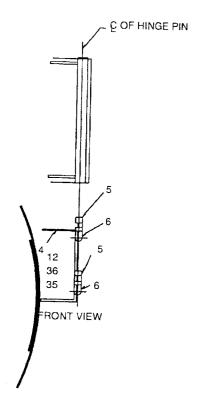
TEMP SENSOR

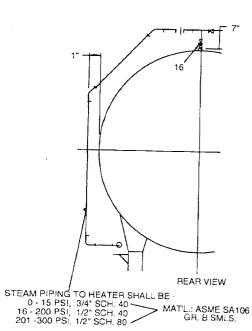
HAWK ONLY

ITEN	MQTY	PART NO.	DESCRIPTION	USED ON	OPTION
	1	838-C-81	TANK - HEATER	5 kw U.S.	0
	1	838-C-35	TANK - HEATER	5 kw CAN	aa
1	1	195-B-238	TANK - HEATER	7-1/2 kw	00
2	1	•	ELEMENT - HEATER	- 112 11	aa/au
3	2	841-1139	U-BOLT	5/7-1/2 kw	00
	2	841-1140	U-BOLT	10-15 kw	<b>QQ</b> <b>QU</b>
4					
5	2	928-45	STRAP - PIPE 3/4"	78"	<b> </b>
6	2	868-14	CAPSCREW - HEX, HD.	78"	
7	2	8-A-656	HEATER BRACKET	5/7-1/2 kw	00 00
8	2	869-36	NUT HEX. 5/16-18	78"	<u> </u>
9	1	507-B-1000	TUBING - OIL RETURN	78"	aa/au
10	1	507-B-999	TUBING - OIL SUPPLY	78"	D3
11	2	845-313	ELBOW FLARED - 9027	-	
12	2	847-1715	SWIVEL JOINT - 9027	-	aa/au
13	1	843-252	STRAINER - 3/4" N.P.T.	78"	QQ/QU
14	1	850-61	PRESSURE GAUGE	<del> </del>	aa/au
15	1	940-2296	RELIEF VALVE - 3/4" N.P.T.	78"	QQ
16	4	952-94	LOCKWASHER - 1/2"	ļ	άΰ
17	1	853-227	GASKET - HEATER	-	
18	8	952-92	LOCKWASHER - 1/4"	-	
19	10	868-138	CAPSCREW HEX. HD.	<del>-</del>	
20	1	847-431	BUSHING - 1-1/4" x 3/4"	78"	
21	2	847-426	BUSHING - 1" x 3/4"		
22	1		LOTS	ALL	D3
23	1		HOTS		D3
24	1	*	LOPS		D3
25	1		HOPS		D3
26	2	847-533	COUPLING 1" X 3/4"		
27	2	847-152	BUSHING 3/4" X 1/2"		
28	2	847-530	COUPLING - RED 3/4" X 1/2"	78"	
29	2	952-114	LOCKWASHER - 5/16"	78"	
30	1	8-A-811	BRACKET, PIPE	78"	QQ/QU
31	1	847-641	COUPLING - RED. 1-1/4" X 3/4"	78"	

OIL CONTROLS		LOTS		HOTS	LOPS	HOPS
		#4 OIL	#5,#6 OIL	ALL	ALL	ALL
	NO INS.	817-926	836-65	836-72	817-1264	
NON-HAWK	IRI/FM/F & I	817-1958	817-1425	817-1425	817-1264	
	KEMPER	817-926	836-65	836-72	817-1264	817-922
HAWK	ALL	817-210 817-39		ENSOR)	817-2098 (PRE 854-11 (SIP	SS SENSOR) HON COIL)

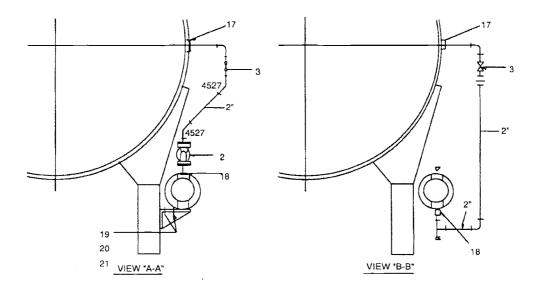


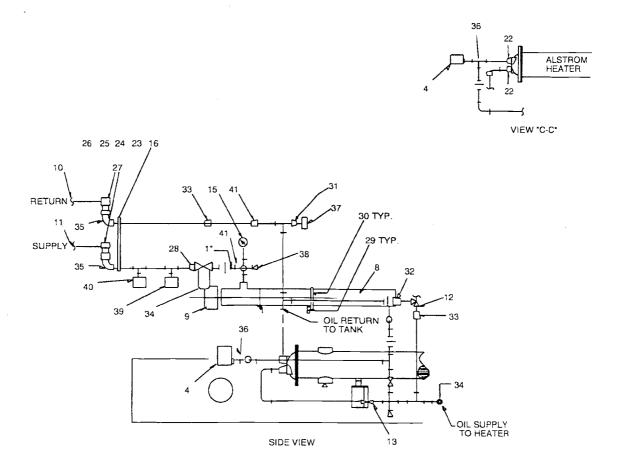


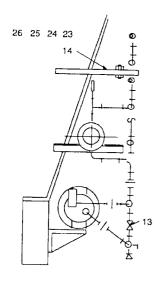


ITEM	ату	PART NO.	DESCRIPTION	USED ON	OPTION
1	1	652-B-24	HEATER TANK	+	B2
2	2	8-A-650	BRACKETS	+	B2
3	1	SEE TABLE	OIL HEATER (PAGE 30)	<u> </u>	B2
4	1	8-A-811	BRACKET-OIL LINE	3.	B2
5	2	845-313	ELBOW 1/2" ODC. X 1/2" NPT.	<del>  .                                   </del>	<u> </u>
6	2	847-1715	BARCO JOINTS	<u> </u>	B2
7	1	940-2296	RELIEF VALVE		B2
8	1	843-252	STRAINER 3/4"	<del> </del>	82
9	1	850-61	OIL PRESSURE GAUGE		B2
10	2	836-A-320	THERMOSTAT (OHT & SHT)	-	B2
11	2	832-311	CONDENSER	-	B2
12	2	928-45	STRAP 3/4"	-	<del> </del> -
13	1	928-45	STRAP 3/4"	0-15#	1
	1	928-44	STRAP 1/2"	16-300#	-
14	1	948-227	SOLENOID VALVE 3/4"	0-15#	50
	1	948-273	SOLENOID VALVE 1/2"	16-300#	B2
4-	1	940-142	CHECK VALVE 3/4"	0-15#	
15	1	940-135	CHECK VALVE 1/2"	16-200#	B2
	1	940-458	CHECK VALVE 1/2"	201-300#	1
10	1	941-142	GLOBE VALVE 3/4"	0-15#	<del>                                     </del>
16	1	941-40	GLOBE VALVE 1/2"	16-200#	B2
	1	941-322	GLOBE VALVE 1/2"	201-300#	1
17	1	8-A-661	BRACKET	-	B2
- 10		850-3	STEAM GAUGE	16-300#	B2
19	1	817-260	REGULATOR, STEAM 1/2*	16-150#	
19	<u> </u>	817-330	REGULATOR, STEAM 1/2"	151-250#	B2
20	1	918-12	REGULATOR, STEAM 1/2"	251-300#	1
21	1	940-142	CHECK VALVE 3/4"		B2
22		934-256	STEAM TRAP	-	B2
23	1	507-B-1000	TUBING OIL RETURN (SEE NOTE 5)		B2
24	+	507-B-999 32-A-2394	TUBING OIL SUPPLY (SEE NOTE 5)		B2
25	1	853-692	GASKET		B2
26	3	847-152	GASKET O-RING		B2
27	2	841-1142	BUSHING, HEX 3/4" X 1/2"		
28	1	854-11	U-BOLT		
29	8	869-21	SIPHON NUT HEX 1/4"-20	16-300#	B2
30	1	847-530			
31	8	841-1458	REDUCING COUPLING 3/4" X 1/2" STUD		
32	1	858-311			
	2-	847-533	FULL COUPLING 1/4" NPT. COUPLING 1" X 3/4"		
34	7		BEDLICING COURLING 1 1/411 X 2/11		
	3	868-405	REDUCING COUPLING 1-1/4" X 3/4"		
	3	869-234	CAPSCREW HEX HD. 1/4*-20 X 7/8" LG.	-	
$\overline{}$	1	+	NUT & LOCKWASHER COMBINATION 1/4"		
	1		HOTS	ALL	D3
	1		LOPS		D3
40	1	-	HOPS		D3
	1	847-424			D3
	<u> </u>	U11-764	BUSHING, HEX 1" X 1/4"		

<sup>\*</sup> SEE PAGE 31

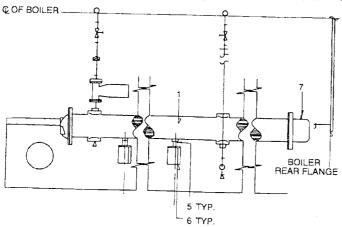






FRONT VIEW

ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OP1
	1	863-269	ALSTROM HEATER	250 H.P.	-
1	1	863-270	ALSTROM HEATER	300 H.P.	B2
1	1	863-260	ALSTROM HEATER	350 H.P.	
2	1	901-292	CIRCULATING PUMP	03011.7	B2
3	2	941-157	VALVE, GATE 2"		- B2
4	1	836-72	THERMOSTAT		B2
_ 5	2	8-A-1301	BRACKET		. B2
6	2	8-A-144	BRACKET	··: <u>-</u> -	B2
7	1	851-155	SIGHT GLASS		B2
8	11	195-B-238	TANK	<del></del>	B2
9	1	SEE TABLE	OIL HEATER ( PAGE 30)	-	_B2
10	1	507-B-1000	TUBING, OIL RETURN (SEE NOTE 5)		B2
11	1	507-B-999	TUBING, OIL SUPPLY (SEE NOTE 5)		B2
12	1 _	940-2116	VALVE, RELIEF 1/2"	-	. B2
13	1	941-143	VALVE, GLOBE 1-1/4"		B2
14	4	869-30	NUT, HEX. 3/8"		B2
15	_1	850-61	GAUGE		B2
16	1	8-A-811	BRACKET	-	B2
17	1.	847-430	BUSHING, RED. 1-1/4" X 1/2"		
18	2	847-453	BUSHING, RED. 3" X 2"	· · · ·	
19	4	868-102	CAPSCREW, HEX. HD. 1/2"-13 X 1/2"	*	
20	4	869-15	NUT, HEX. 1/4"-20		-
21	4	952-94	LOCKWASHER 3/8"	1 - 1	***
_22	2	847-442	BUSHING, RED. 2" X 1-1/4"		
23	2	928-45	PIPE STRAP 3/4"		
24	2	868-14	CAPSCREW, HEX HD. 5/16"-18 X 3/4"		
25	2	952-114	LOCKWASHER 5/16"	- ·	
26 27	2	869-36	NUT, HEX. 5/16"-18		
1	2	845-313	ELBOW, 1/2" ODC X 1/2" NPT X 90		
28	_3	847-152	BUSHING, RED. 3/4" X 1/2"		
29 30	2 4	7-A-52 952-93	U-BOLT		
31	2		LOCKWASHER 3/8"	*	
32	2	847-453	BUSHING, RED. 3" X 2"		
33		8-A-656	BRACKET, OIL HEATER		B2
	1	847-530	COUPLING, RED. 3/4" X 1/2"		
34	- <u>!</u>	843-252 847-1715	STRAINER		B2
36	2		SWIVEL JOINT, 1/2" NPT		B2¨
37	 1	847-62	TEE,1-1/4" X 1/2" X 1-1/4"	-	B2
	4		LOTS		D3
38	1		HOTS		D3
40	1 .		LOPS	-	D3 <sup>'</sup>
41	_' 2	P47 500	HOPS		D3 :
71.	٤ .	847-533	COUPLING, RED. 1" X 3/4"		



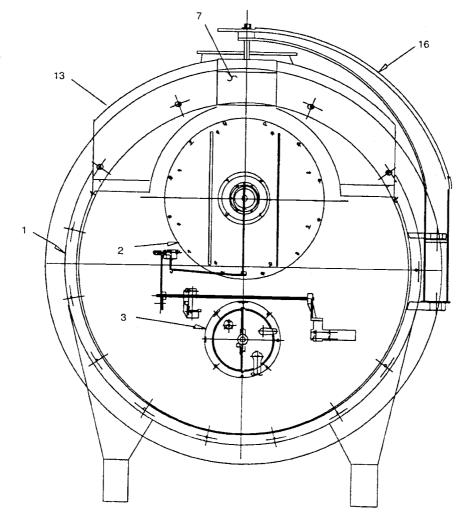
RIGHT HAND SIDE VIEW

HEAVY OIL ALSTROM HEATER HOT WATER CB,CB-LE

\* SEE TABLE PAGE 31

ITEM #1 P/N					
РРМ	STD.	HOI			
60 PPM	132D1688(RH)	132D2093(RH)			
50 7 7 70	132-1720(LH)	132-2094(LH)			
30,25 PPM	132-1721(RH)	132-2095(RH)			
	132-1722(LH)	132-2096(LH)			
20 PPM	132-1723(RH)	132-2097(RH)			
	132-1724(LH)	132-2098(LH)			

		ITEM #4 P/N	
BOILER PRESS.	BOILER H.P.	SHELL AND BASEFRAM WELDMENT & ASSEME	
		PRESS. ASSY	SKID DETAIL
30# - H.W	250 300 350	270 02244 (270D02241) 270 02245 270 02246	
125# . H.W	250 300	270 02250 (270D02247) 270 02251 L	
150# - HTHW	350 250 300	270 02252 V 270 02256 (270D02253) 270 02257	
15# ST.	350 250 300	270 02258 V 270 02220 (270D02217) 270 02221 L	
150# ST.	350 250 300	270 02222 270 02226 (270D02223) 270 02227	146 333
200# ST	350 250 300	270 02228 V 270 02232 (270D02229) 270 02233	
250#	350 250 300	270 02234	
ST. 300# +	350 250		
ST.	300 350		



ITEM	QTY	PART NO.	DESCRIPTION	OPTION
1	1 1	SEE TABLE	FRONT HEAD ASSEMBLY (STD.132-D-1688) (HOI.132-D-2093)	A2
2	1	146-D-13	BLOWER ASSEMBLY	AZ
3	1	146-D-120	BURNER HSG SUPP., FRT HD PLATE, & BURNER DRAWER	<del></del>
4	1	SEE TABLE	PRESSURE VESSEL ASSEMBLY (SEE NOTE #1)	A1
5	1	465-D-625	REAR HEAD ASSEMBLY (NOT SHOWN)	43
6	1	146-D-102	FURNACE LINER AND BRICKING (SEE PAGE 9-45 & 9-46)	43
7	1	461-C-576	AIR HOOD, CENTER	A2
8	1_	32-C-2532	GASKET, BLOWER ASSEMBLY	
9	33	841-507	SPRING CLIPS, GASKET (656-B-7882)	A2
10	1	32-C-2543	GASKET-BLOWER CARTRIDGE (146-C-28)	
	1	476-C-237	LINKAGE ASSEMBLY, IFGR (GAS ONLY)	A4
11	1	476-262	LINKAGE ASSEMBLY, IFGR (LIGHT OIL ONLY)	A4
	1	476-C-238	LINKAGE ASSEMBLY, IFGR 20-30 PPM (COMB. L.O. & GAS)	A4 A4
	1	476-C-299	LINKAGE ASSEMBLY, IFGR 60 PPM (COMB. L.O. & GAS)	——————————————————————————————————————
	1	146-D-208	INSTALLATION HEAVY OIL ISOLATION SYSTEM	A4
12	11	146-C-136	AIR COMPRESSOR ASSEMBLY (NOT SHOWN)	
13	1	656-C-7726	AIR HOOD ASSEMBLY	A2
14	2	32-B-899	GASKET, FRONT AND REAR HEAD 78" (656-B-7882)	AZ
15	1	465-C-1634	FRONT HEAD INSULATION	
16	1	146-C-38	DAVIT ASSEMBLY, FRONT HEAD 78"	A2
17	1	146-C-261	INSULATION & LAGGING (THOMASVILLE)	
18	1	146-D-15	SAFETY VALVES	

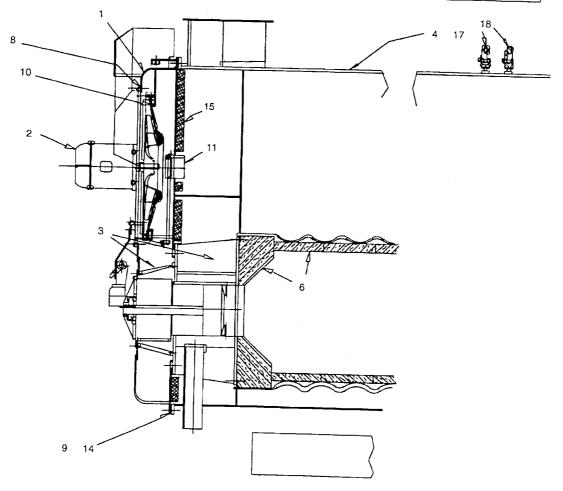


TABLE ITEM 1						
BOILEF H.P.	BOILER MOTOR		FUEL	PART NO.		
	7.5	50	GAS	192-C-80		
250	10	50	OIL/COMB.	192-C-77		
2.00	7.5	60	GAS	192-C-76		
	7.5	00	OIL/COMB.	192-C-76		
	10	50	GAS	192-C-78		
300	15	30	OIL/COMB.	192-C-78		
	7.5	60	GAS	192-C-80		
	10	00	OIL/COMB.	192-C-77		
	15	50	GAS	192-C-79		
350	20		OIL/COMB.	192-C-79		
550	15	60	GAS	192-C-78		
	15	00	OIL/COMB.	192-C-78		

$\overline{}$		·	
ITEM	QTY	PART NO.	DESCRIPTION
1	1	SEE TABLE	IMPELLER
2	1	SEE TABLE	SPACER, IMPELLER
3	1	SEE TABLE	WASHER
4	1	SEE TABLE	NUT, SELF LOCKING, JAM
5	-	SEE TABLE	WASHER, SPACER
6	1	85-D-263	SUPPORT, MOTOR
7	1	22-B-237	PLATE, DIFFUSER
8	1	19-A-375	COVER, SHAFT
9	2	860-201	SCREW, MACH., RD. HD.
			#10-24 X 3/8" LG.
10	2	952-117	LOCKWASHER, #10
11	1	32-A-919	GASKET, AIR HOOD
12	8	868-175	CAPSCREW, HEX. HD.
	Ů		12"-12 X 1-3/4" LG.
13	10	952-94	LOCKWASHER, 1/2"
14	9	869-15	NUT, HEX. 1/2"-13
15	8	77-A-103	SPACER
16	15	952-93	LOCKWASHER, 3/8"
17	11	869-30	NUT, HEX. 3/8"-16
18	-	SEE TABLE	WASHER, SPACER .005
19	-	SEE TABLE	WASHER, SPACER 1/16"

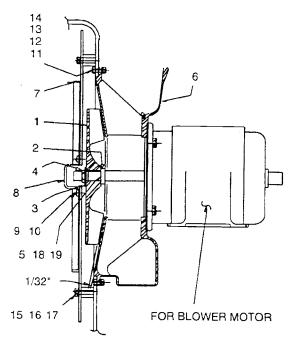


TABLE ITEMS 2 3 4 & 5					
50-60 HZ.					
CB 250	CB 250 CB 300				
	GAS	OIL/COMB.	CB 350		
77-A-101	77-A-101	77-A-102	77-A-102		
952-289	952-289	952-289 952-225			
869-119	869-119	869-177			
91-60	91-60	91-79			

TABLE ITEMS 18 & 19					
50-60 HZ.					
CB 250	CB 30	CB 350			
GAS OIL/C			CB 350		
91-59	91-59 91-59 91-78				
91-61	91-61 91-61 91-80				



300 #	151 # 250 #	16 <sup>#</sup> 150 #	15 #				78" PRESSURE CO	ONTROLS BILL OF MATERIAL
PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817-111	817-111	817-110	817-16		1	SEE TABLE	CONTROL PRESSURE (OLC)	CB780/CB100E/E110
817-2096	817-2096	817-2095	817-2094	7 '	1	SEE TABLE	SENSOR - PRESSURE	HAWK
817-900	817-900	817-109	817-415	2	1	SEE TABLE	CONTROL PRESSURE (HLC)	
817-234	817-234	817-204	817-251	3	1	SEE TABLE	CONTROL PRESSURE (MC)	CB780/CB100E/E110
857-726	857-448	857-448	857-448	4	. 3	SEE TABLE	NIPPLE - 1/4" x 1-1/2"	-

BOILER H.P.	DIM."Å
250 H.P.	39*
300-350 H.P.	42"

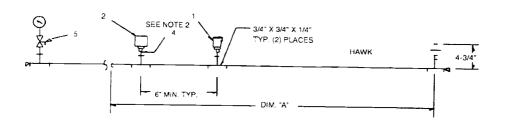
ITEM #4 QTY OF 2 FOR HAWK OR FOR 15 & 20 H.P. CB780/E110.

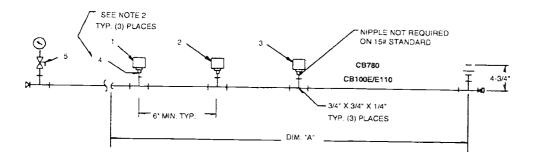
### NOTES:

1 UNLESS OTHERWISE NOTED, PIPE MATL TO BE ASME SA 106 GR B SMLS. INSTALLATIONS UP TO 150 PSI CAN USE 3/4" SCHEDULE 40 (MIN) AND 150 PSI M.J. FITTINGS GREATER THAN 150 PSI M.JST BE 3/4" SCH. 80 AND 300# M.I FITTINGS.

2. ITEM 4 TO BE BRASS FOR PSI'S THRU 250 PSI, 300 PSI REQUIRES SCHEDULE, 80 NIPPLE.

3. ALL DIMENSIONS ARE APPROX.



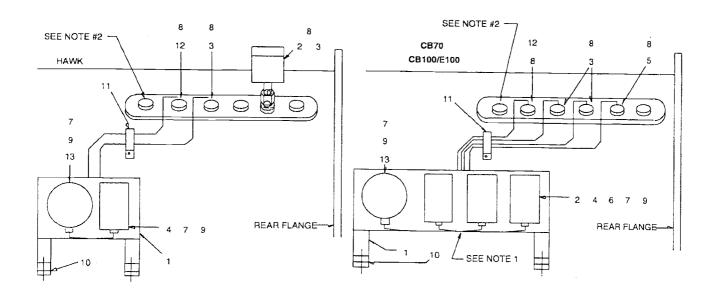


CB76	CB70/CB100/E100		HAWK		HAWK
30	0-125 HW		HTHW	30	125 HW
QTY	P/N	QT.	Y P/N	aty	P/N
	8-967	-	8-937	1 .	8-937
	8-995		8-2933	][-	8-2933
-	817-1244	]	817-2099		817-2100
-	817-399		817-699	-	817-399
-	817-1050		817-1275	-	817-1050
1	817-378	-	-	-	
1	817-400	-	-	-	-
9	-	6		6	-
4	-	3		3	· · · · · ·
9	-	6		6	-

	BILL OF MATERIAL						
ІТЕМ	ΩΤΥ	PART NO.	DESCRIPTION	WHERE USED			
1	1	-	BRACKET (8B937)	78*			
2	1		TEMPERATURE CONTROL (MC)	-			
3	2		WELL SEPARABLE	-			
4	1		TEMPERATURE CONTROL (HLC)				
5	-		WELL SEPARABLE	_			
6	-		TEMPERATURE CONTROL (OLC)				
7	-	860-4	MACH. SCR. #10-32 x 3/4"	-			
8	-	847-152	BUSHING RED 3/4" x 1/2"	-			
9	[	869-9	NUT MACH. SCR. #10-32				
10	4	841-571	SHT. MTL. SCR. #10-32 x 5/8"				
11	1	928-39	STRAP - PIPE	-			
12	1	817-641	SOCKET SEPARABLE	-			
13	1	937-27	THERMOMETER	78"			

### NOTES:

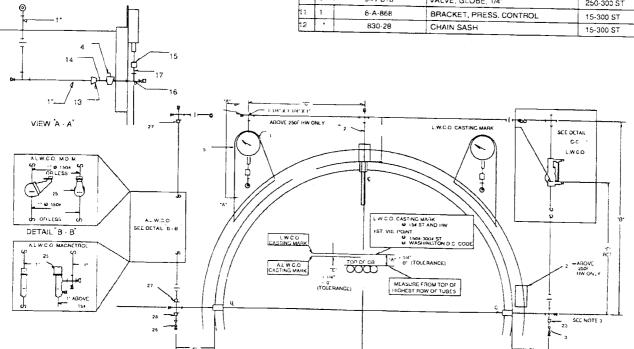
- 1. INSTALL PER ELECTRICAL SCHEMATIC.
- 2. ALL UNUSED FITTINGS MUST BE CAPPED.



	,	
	PRESSURE	CB 78*
.A.	_15# ST	0*
"	150-300# ST	3.
	ALL HW	3-1/2"
"B"	ALL	45"
'r'C"	ALL	26-1/2"
-D.	ALL	21-1/2"
	15# ST	1/2*
"E"	150-250# ST	1"
	ALL HW	1.
	15# ST	18-1/4"
·F-	150# ST	22-5/8*
AEF.	200-300# ST	21-7/8*
	ALL HW	21'
** FOR	LE USE DIM "C	TABLE BELC

		4	
	PRESSURE	CBLE 78"	į
,C.	ALL	45-3/8*	1

	Т-	PARTI	<u>vo</u>		·
ITEN	QTY		MAGNETROL	DESCRIPTION	USED ON
	1	850-	264	PRESSURE GAUGE	15 ST
	1	850-	104	PRESSURE GAUGE	150-200 ST/150 HTHW
1	1	850-	150	PRESSURE GAUGE	250 ST
'	1		850-172	PRESSURE GAUGE	300 ST
	1	850-101		TEMPERATURE GAUGE	30 HW
	1	850-103		TEMPERATURE GAUGE	125 HW
	1	817-95	817-163	LOW WATER CUT-OFF	15 ST
	1	817-94	817-163	LOW WATER CUT OFF	150 ST
2	1	817-304	817-163	LOW WATER CUT-OFF	200-250 ST
	1		817-1962	LOW WATER CUT-OFF	300 ST
Δ	1	817-2348		LOW WATER CUT-OFF (850-M PROBE)	0-160 PSI. (UP TO 250F) HW
	1	817-2305		WATER LEVEL PROBE TYPE, MDL. 750	
ļ	1	817-2306	REMOTE S	ENSOR, PROBE HOLDER, MDL. 750	ABOVE 250F HW
	1	817-2307	PROBE EXT	, 24°LG, FOR REMOTE SENSOR, MDL. 75	ONLY
	1	941-1790		VALVE, BALL 3/4"	15-200 ST
3	1	941-401		VALVE, GLOBE 3/4*	250 ST
_	2	941-	401	VALVE, GLOBE 3/4"	300 ST
	2	825-31		COCK, UNION, BRASS (1 @ FINAL ASSY.)	15-250 ST
4	2		941-318	VALVE, GLOBE 1/4", BRASS	300 ST
_	1	825-31		COCK, UNION, BRASS	ALL HW
	1	8-A-1	728	BRACKET, STEAM GAUGE	78* CB
5	1	8-A-3	3172	BRACKET, STEAM GAUGE LH MOUNTING	78" LE
	1	8-318	31	BRACKET, STEAM GAUGE RH MOUNTING	78" LE
١	1	851-44	B51-38	GAUGE, GLASS	15-150 ST
6	1	851-199	851-38	GAUGE, GLASS	200-250 ST
	1		851-321	GAUGE, GLASS	300 ST
7	4	912-34	912-34	ROD, GAUGE GLASS	15-150 ST ONLY
_	4	912-85	912-34	ROD, GAUGE GLASS	200-250 ST ONLY
a	1	825-3	352	SET, GAUGE GLASS	15-250 ST
	1		825-357	SET, GAUGE GLASS	300 ST
-					
0	1	941-		VALVE, BALL 1/4"	15-200 ST
4	1 /	941.0		VALVE, GLOBE, 1/4*	250-300 ST
1	1	8-A-8		BRACKET, PRESS. CONTROL	15-300 ST
2		830-	28	CHAIN SASH	15-300 ST



750-91

W.C.-MAIN & AUX. CB

### OPTIONAL REPLACEMENT FOR ITEM 2

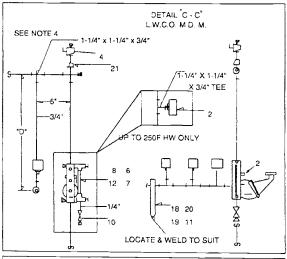
LWCO W/ MODULATING SWITCH 193-7 & 194-7

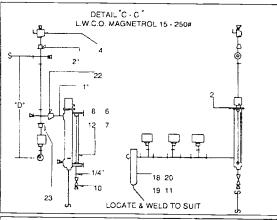
15-150# ST	817-1307
200-250# ST	817-1211

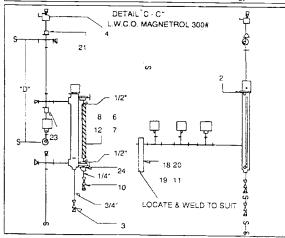
LWCO W	/ SWI	ТСН	FOR	MOTORIZED	FEED	VALVE
	4.50	400	0 40			

1007 1007 4 1151	
15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304

TEN	OTV		PART NO.		DESCRIPTION	UCED ON
HEN	OTY	15-150#	200-250#	300#	DESCRIPTION	USED ON
13	1	847-1687	858-1009	858-1009	COUPLING 1" X 1/4"	
14	1	857-448		857-726	BRASS NIPPLE, 1/4" x 1-1/2"	
15	1	858-856		858-768	COUPLING 1/4" R.H. THREAD	
16	1	859-54		859-32	BRASS TEE 1/4"	
17	1	857-452		857-676	BRASS NPL. (X-HEAVY) 1/4" x 1-1/2"	-
18	1	869-234			NUT & LOCKWASHER 1/4*	-
19	1	928-44			ONE-HOLE CLAMP	
20	1	868-136			CAPSCREW HEX. HD. 1/4-20 x 3/4"	-
21	1	847-428	84	47-470	BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432 8	47-472		BUSHING 1-1/4" x 1"	MAGNETRO
23	1	847-431	8-	17-471	BUSHING 1-1/4" x 3/4"	ALL ST
2.5	2	847-431	84	47 <b>-4</b> 71	BUSHING 1-1/4" x 3/4"	MAGNETRO
24	1			847-612	BUSHING 1/2" X 1/4"	MAGNETRO







# ALW.CO. MCD.M.

	1	817-98	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
25	1	817-97	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
	1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
26	1	941-1790	VALVE, BALL 3/4"	15-200#
20	1	941-401	VALVE, BALL 3/4"	250#
27	2	847-432	BUSHING 1-1/4" x 1"	15-150# ONLY
28	1	847-431	BUSHING 1-1/4" x 3/4"	15 150#
	1_	847-471	BUSHING 1-1/4" x 3/4"	200-250#

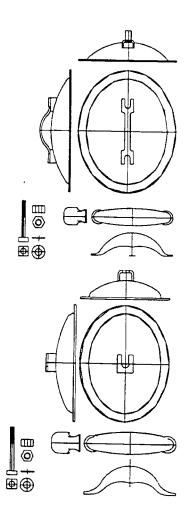
### A.L.W.C.O. MAGNETROL

25	1	817-301	CONTROL, AUX. L.W.C.O.	<b>≭</b> 15-250#
	1	817-1251	CONTROL, AUX, L.W.C.O.	<b>4300#</b>
26	1	941-1790	VALVE, BALL 3/4"	×15-200#
20	1	941-401	VALVE, BALL 3/4"	<b>4</b> 250-300#
27	2	847-432	BUSHING 1-1/4" x 1"	15-150#
	2	847-472	BUSHING 1-1/4" x 1"	200-300#
28	1	847-431	BUSHING 1-1/4" x 3/4"	15-150#
	1	847-471	BUSHING 1-1/4" x 3/4"	200-300#

PF	RESSI	JRE VESSEL	. 78" DIA. 15# ST, HW,30# ,125# HW. Sta. & LE	
ITM	REQ	PART-NO.	DESCRIPTION	
1	2	953-00050	YOKE, MANHOLE, PRESSED STEEL	
2	2	869-00065	NUT, HEX,HEAVY 3/4-10 UNC-2B ASTM-A3	
3	2	952-00124	WASHER, FLAT, PLAIN, #10GA, SAE TYPE	
4	1	853-00939	GASKET, MANHOLE, 12" X 16"	
5	1	821-00207	COVER, MANHOLE, SA-285 GR.C PVQ	
6	6	104-00449	YOKE, HANDHOLE, CAST IRON	
7	6	869-00017	NUT, HEX, FINISHED, PLAIN, 5/8-11 UNC-2	
8	6	952-00101	WASHER,FLAT,PLAIN,#13GA,SAE TYPE	
9	6	853-00935	GASKET, HANDHOLE, 3-1/4" X 4-1/2"	
10	6	258-00010	COVER, HANDHOLE,	

TM REQ PART-NO. DESCRII   T   2   953-00050   YOKE, MANHOLE,   2   2   869-00065   NUT,HEX,HEAVY,3/   3   2   952-00124   WASHER,FLAT,PLA	PRESSED STEEL, 4-10 UNC-2B,ASTM-A3
2 2 869-00065 NUT,HEX,HEAVY,3/	4-10 UNC-2B,ASTM-A3
2 2 869-00065 NUT,HEX,HEAVY,3/ 3 2 952-00124 WASHER,FLAT,PLA	4-10 UNC-2B,ASTM-A3
3 2 952-00124 WASHER,FLAT,PLA	
	NN,#10GA,SAE TYPE
4 1 853-00939 GASKET, MANHOLI	E, 12" X 16"
5 1 821-00207 COVER, MANHOLE.	SA-285 GR.C PVQ
6 6 953-00048 YOKE, HANDHOLE,	2 PRONG FORGED
7 6 869-00017 NUT,HEX,FINISHED	D.PLAIN,5/8-11 UNC-2
8 6 952-00101 WASHER,FLAT,PLA	IN,#13GA,SAE TYPE
9 6 853-00935 GASKET.HANDHOL	
10 6 258-00010 HANDHOLE COVER	R ASSY., 78 & 96"

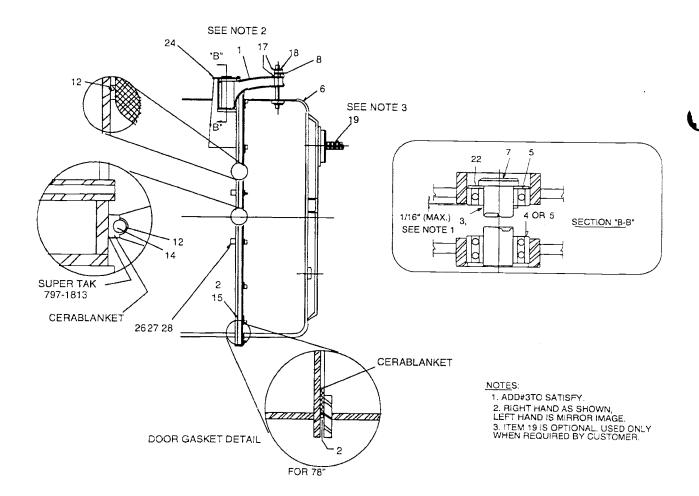
	PRESSURE VESSEL LE 78" 200#,250# ST. Std & LE					
ITM	REQ	PART-NO.	DESCRIPTION			
1	2	953-00050	YOKE, MANHOLE, PRESSED STEEL,			
2	2	869-00065	NUT, HEX, HEAVY, 3/4-10 UNC-2B, ASTM-A3			
3	2	952-00124	WASHER, FLAT, PLAIN, #10GA, SAE TYPE			
4	1	853-01044	GASKET, MANHOLE, 12" X 16"			
5	1	821-00207	COVER,MANHOLE,SA-285 GR.C PVQ			
6	6	953-00048	YOKE, HANDHOLE, 2 PRONG FORGED			
7	6	869-00017	NUT, HEX, FINISHED, PLAIN, 5/8-11 UNC-2			
8	6	952-00101	WASHER,FLAT,PLAIN,#13GA,SAE TYPE			
9	6	853-01042	GASKET, HANDHOLE, 3-1/4" X 4-1/2"			
10	6	258-00010	HANDHOLE COVER ASSY., 78 & 96"			

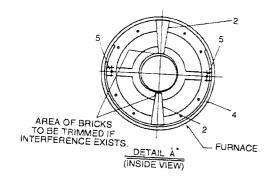


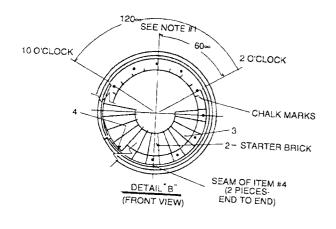
# Chapter 9

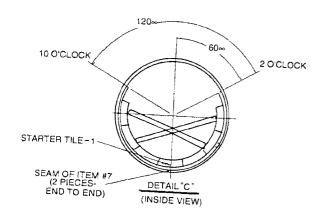
	BILL	OF MATER	IAL FOR 78 DIA BOILER		
ITEM	OTY.	PART #	DESCRIPTION	USED ON	OPTION
- 1	1	287-B-41	DAVIT ARM ASSEMBLY, REAR R.	Н.	A2
2	1	32-899	GASKET	i — — —	A2
3	1	77-A-385	SPACER FOR 78" REAR DAVIT AS	SY.	A2
4	1	807-31	BEARING - DOUBLE ROW	·	A2
5	1	807-319	BEARING, BALL - SINGLE ROW	_	A2
6	1		EHEAD, REAR INSULATED		43.46,4
7	1	56-A-25	PIN, HINGE, DAVIT - REAR		A2
8		-	NOT USED FOR 78" DIA. BOILER		
9	14	868-594	CAPSCREW, HEX.HD.7/8*-9 X 5-1/	2" _G.	1
10	-	-	NOT USED		
11		853-348	ROPE GASKET, 1/4"		
12	25 LB\$	872-26	CEMENT		
13			NOT USED		
14		. 853-1036	ROPE - 1-1/2" DIA.		
15	36	841-507	FASTENER		
16	14	952-103	WASHER, FLAT, NO. 10		
17	1	952-193	WASHER, FLAT, 1-3/8"		
18	1	869-399	NUT. ELASTIC LOCKNUT, 1-1/4".	7	
19	-	428-A-37	COMBUSTION RELIEF DOOR, 121	OPTIONAL	46, 47
20	-	-	NOT USED		
_21		550-A-42	CAP, SIGHT HOLE ASSEMBLY		A2
22	1	914-158	RING, RETAINER		A2

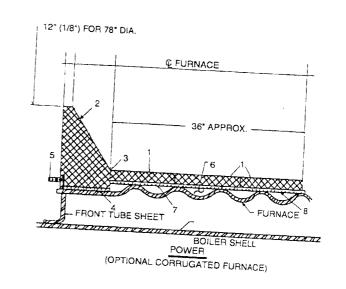
# CUSTOMER SERVICE AND PARTS 9 16

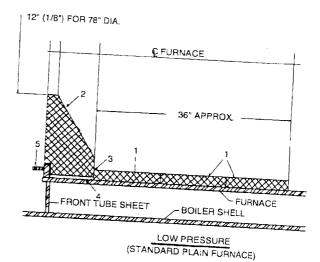












			BASIC BILL OF MATERIAL FURNACE LINER & BRICKING - 78"	
ITEM	QTY	PART No.	DESCRIPTION	USED ON
٠	36	94-A-204	TILE - 34" O.D. FURNACE (CORRUGATED)	250-350 H.P. (POWER ONLY)
	39	94-A-204	TILE - 34" 0.D. FURNACE (PLAIN)	250-350 H.P. (L.P. ONLY)
2	24	94-B-343	REFRACTORY - ARCH BRICK	250-350 H.P. (ALL)
3	10 LBS.	872-390	CEMENT - JOINT MORTAR	250-350 H.P. (ALL)
4	2	872-655	SIZED INSUL. 1/4" X 6-3/4" X 48" LG.	250-800 H.P. (ALL)
5	12	841-665	STUD, 1/2"-13 UNC X 2" LG.	250-350 H.P. (ALL)
6	15 LBS.	872-162	REFRACTORY - VEE BLOCK MIX	250-350 H.P. (POWER ONLY)
7	2	872-657	SIZED INSUL. 1/4" X 21" X 48" LG.	250-350 H.P. (POWER ONLY)
8	2	872-656	SIZED INSUL. 1/4" X 16" X 48" LG.	250-350 H.P. (POWER ONLY)

		OPTIONAL	BASIC BILL OF MATERIAL CORRUGATED FURNACE LINER & BRICKIN	G - CB & LE 78"		
ITEM QTY	QTY	PART No.	D. DESCRIPTION	USED ON		
				H.P.	PRESSURE	
1	36	094-A-00204	TILE - 34" O.D. FURNACE (CORRUGATED)	CB & LE 250-350	125#-250#	
2	24	094-B-00343	REFRACTORY - ARCH BRICK	CB & LE 250-350	125#-250#	
3	10 LBS.	872-00390	CEMENT - JOINT MORTAR	CB & LE 250-350	125#-250#	
4	2	872-00655	SIZED INSUL. 1/4" X 6-3/4" X 48" LG.	CB & LE 250-350	125#-250#	
5	12	841-00665	STUD, 1/2"-13 UNC X 2" LG.	CB & LE 250-350	125#-250#	
6	15 LBS.	872-00162	REFRACTORY - VEE BLOCK MIX	CB & LE 250-350	125#-250#	
7	2	872-00657	SIZED INSUL. 1/4" X 21" X 48" LG.	CB & LE 250-350	125#-250#	
8	2	872-00656	SIZED INSUL. 1/4" X 16" X 48" LG.	CB & LE 250-350	125#-250#	



Performance Proven Worldwide

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